Performance Analysis of Various Active Harmonic Filters through Literature Survey

Pankaj Kumar Verma[1] & Prof. A. K. Jhala[2]
[1]*Reseacrh Scholar,* [2]*Research Guide & HOD, Department of Electrical Engineering*
RKDF College of Engineering, Bhopal

Abstract- In this review paper we have studied various techniques of harmonic filters designed for large-power applications, where complex digital control circuit and expensive batteries are often used. In this study, a simple and low-cost active harmonic filters circuit using an analog-based hysteresis current controller and capacitive energy storage. The filter is intended to be a low-power add-on unit to reduce the AC harmonic currents of existing electronic equipment (e.g., personal computers), which impose nonlinear loads to the AC mains. The operation principle, design criteria, and control strategy of the proposed filter are discussed. In recent years both power engineers and consumers have been giving focus on the "electrical power quality" i.e. degradation of voltage and current due to harmonics, low power factor etc. Nearly two decades ago majority loads used by the consumers are passive and linear in nature, with a few non-linear loads thus having less impact on the power system. The harmonic current pollute the power system causing problems such as transformer overheating, voltage quality degradation, rotary machine vibration, destruction of electric power components and malfunctioning of medical facilities etc. To provide clean power at the consumer-end active power filter may be used.

Keywords: Harmonic Active Filters,

I. INTRODUCTION

The application of harmonic electronic in power conversion shows drawbacks that lead to power quality problems which could relate to harmonics affecting communication interference, heating, solid-state devices malfunction, resonance. Solutions involve several techniques that include the use of passive and active harmonic filter. A more advance approach is the use of hybrid filters amongst other involves the use of both the passive filter and shunt APF in combination. They are being used to eliminate both the lower order and higher order harmonics. The passive filter is normally designed to eliminate the bulk of load-current harmonic leaving the more complex problems to be solved by the APF.

Shunt APF normally operates using pulse width modulation (PWM) inverter techniques to inject the required non-sinusoidal current requirements of nonlinear loads but is complex with the number of switches in use . Another approach is the use of series active harmonic filter that uses basic bridge-diode circuit, boost circuit and an inductor. Single phase converter produces a relatively high proportion of ac ripple voltage at its dc terminal; it is undesirable because of its heat producing effect. A smoothing needed to get continuous operation. It can be minimized by increasing number of pulses. Three phase ac supply with a suitable transformer connection permits an increasing the pulse number. When the number of pulses increased output voltage gets smoothen. So here it has been analyzed an extension of single phase hybrid active harmonic filter.

II. ACTIVE HARMONIC FILTER

Electric Power Quality

Power system is designed to operate at a frequencies of 50 or 60 Hz. However, certain types of non-linear loads produce current and voltages with frequencies that are integer multiple of the fundamental frequency. These frequency components known as harmonic pollution and is having adverse effect on the power system network. This is generally a consumer driven issue, so PQ problem is defined as, "any occurrence manifested in voltage, current, or frequency deviations that results in damage, upset, failure, or disoperation of end use equipment."

Harmonic Distortion Due to increased use of nonlinear loads, one of the PQ issues that have been gaining continuous attention is the harmonic distortion. The nonlinear loads control the flow of power by drawing currents only during certain intervals of the fundamental period. Hence the current supplied by the source becomes non-sinusoidal and contains higher percentage of harmonic components. Fig. 1 shows that any non-sinusoidal signal can be expressed as sum of pure sinusoids. The sum of sinusoids is referred to as a Fourier series. By using Fourier analysis, a periodic distorted waveform can be decomposed into an infinite series containing DC component, fundamental component (50/60 Hz for power systems) and its integer multiples called the harmonic components. The harmonic number (h) usually specifies a harmonic component, which is the ratio of its frequency to the fundamental frequency [2]. The total harmonic distortion is the most common measurement index of measuring harmonic distortion [2], [10]. THD applies to both current and voltage and is defined as the root-mean-square (rms) value of harmonics divided by the rms value of the fundamental, and then multiplied by 100% as shown in the following equation:

$$THD = \frac{\sqrt{\sum_{k=2} h_k{}^2}}{h_1} \times 100$$

where hk is the rms value of harmonic component k of the quantity h

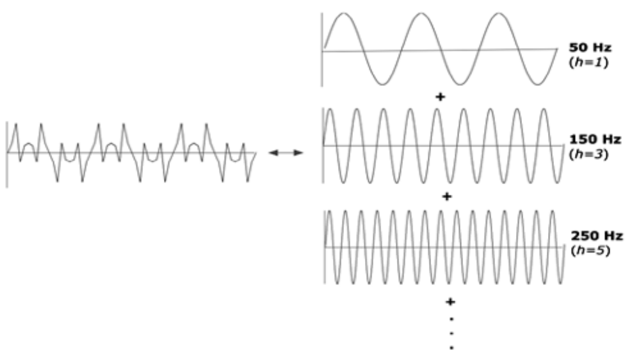

Fig. 1. Non-Sinusoidal signal expressed as sum of sum of sinusoidal signals

Harmonic Distortion Effects on Power Quality When a nonlinear load is fed from a sinusoidal supply, non-sinusoid, distorted current containing harmonics will be drawn from the supply. A voltage drop for each harmonic will be produced when this harmonic current will pass through the source impedance resulting in harmonic voltage at the PCC. The amount of voltage distortion depends on the source impedance and current. Harmonics has numerous undesirable effects on electric PQ. Unexplained computer network failures, premature motor burnouts, humming in telecommunication lines, and transformer overheating are only a few of the damages that quality problems may bring into home and industrial installations. What may seem like minor quality problems may bring whole factories to a standstill.

III. LITERATURE SURVEY

In the year of 2014 Jinwei He; Yun Wei Li; Blaabjerg, F.; Xiongfei Wang,[1] Proposed by The increasing application of nonlinear loads may cause distribution system power quality issues. In order to utilize distributed generation (DG) unit interfacing converters to actively compensate harmonics, this research work proposes an enhanced current control approach, which seamlessly integrates system harmonic mitigation capabilities with the primary DG power generation function. As the proposed current controller has two well-decoupled control branches to independently control fundamental and harmonic DG currents, local nonlinear load harmonic current detection and distribution system harmonic voltage detection are not necessary for the proposed harmonic compensation method. Moreover, a closed-loop power control scheme is employed to directly derive the fundamental current reference without using any phase-locked loops (PLL). The proposed power control scheme effectively eliminates the impacts of steady-state fundamental current tracking errors in the DG units. Thus, an accurate power control is realized even when the harmonic compensation functions are activated. In addition, this work also briefly discusses the performance of the proposed method when DG unit is connected to a grid with frequency deviation. Simulated and experimental results from a single-phase DG unit validate the correctness of the proposed methods.

In the year of 2014 Raveendran, V.; Nair, M.G.,[2] in the study of about vehicle-to-grid (V2G) services such as reactive power compensation and harmonic elimination by employing the converters used in electric vehicle charging stations (Smartparks) as shunt active filters (SAF). Batteries can be charged using the bidirectional converters during off peak hours. The parks can supply stored energy to the grid if they have excess solar energy for charging and also support the grid by providing compensation. By incorporating modified ICosΦ algorithm the complete simulation of hysteresis current controlled voltage source converter (VSC) acting as a Smartpark is presented. For inductive and non-linear loads simulations have been performed in Matlab under steady state and transient conditions. The feasibility of this simple and efficient controller to be used as SAF is demonstrated by the simulation results.

In the year of 2014 Jinwei He; Yun Wei Li; Blaabjerg, F.,[3] discusses to accomplish superior harmonic compensation performance using distributed generation (DG) unit power electronics interfaces, an adaptive hybrid voltage and current controlled method (HCM) is proposed in this research work.

It shows that the proposed adaptive HCM can reduce the numbers of low-pass/bandpass filters in the DG unit digital controller. Moreover, phase-locked loops are not necessary as the microgrid frequency deviation can be automatically identified by the power control loop. Consequently, the proposed control method provides opportunities to reduce DG control complexity, without affecting the harmonic compensation performance. Comprehensive simulated and experimental results from a single-phase microgrid are provided to verify the feasibility of the proposed adaptive HCM approach.

In the year of 2013 Quintana, P.; Garcia, J.; Corominas, E.L.; Calleja, A.J.; Garcia, P.,[4] presents a methodology to improve the line current THD of a distribution line configuration with multiple non-linear loads, by means of a simple algorithm based on sensing only the voltage at the Point of Common Coupling (PCC), thus avoiding the use of line current measurement. Firstly, the effect of conventional low frequency electromagnetic lighting ballasts is quantified by means of actual waveforms that yield to a new a circuital model for simulation. The effect on the line current distortion of such loads, generating mainly 3rd and 5th harmonics on the line current, is then studied. Then, the proposed configuration is presented and analyzed, resulting in a significant reduction of these harmonics and also the final THD of the line current. In this work, a scheme of distributed current controlled converters is proposed for mitigating the line current THD. Having the non-linear loads inductive behavior, the proposed control must be implemented using a full bridge topology in order to achieve the requirements of active/reactive power compensation.

In the year of 2013 Ravichandran, C.; Premalatha, L.; Saravanakumar, R.,[5] presented to the two topologies of current controlled voltage source inverter (CCVSI) based active power filter using direct current control technique for compensating unbalanced loads in a three-phase four-wire system is proposed. In this method the harmonic compensation current reference is generated without introducing any additional harmonic extraction filtering circuits. A control approach for balancing the DC voltage of the active power filter is incorporated to cover the system losses. The proposed shunt active power filter compensates harmonics and reactive power in all three phases as well as the neutral current. To regulate and balance the dc capacitor voltage, a current control method using hysteresis controller is proposed. The simulation results based on MATLABSimulink tool demonstrate the feasibility of the proposed topologies. The total harmonic distortion of source current has been calculated and compared for two topologies to demonstrate important compensation characteristic of proposed control methodology of shunt active power filter.

In the year of 2013 Geetha, K.; Sangeetha, B.,[6] discusses to The global warming concerns, diminishing fossil fuels have made it necessary to move towards Renewable Energy Sources (RES) as a future energy solution. As a result of this, Renewable energy resources (RES) connected with distribution systems increases gradually. This paper presents a narrative control strategy for the implementation of a three-phase four wire currentcontrolled Voltage Source Inverter (CC-VSI) as both power quality improvement and wind energy extraction. For power quality improvement, the inverter works as a shunt active power filter. The output of wind energy source is a DC voltage that determines the DC-bus voltage and the dc-side voltage is controlled by a fuzzy PI controller. The new approach has been illustrated in order to find the best way to reduce network harmonic currents of the connected load. All of the studies have been carried out through dynamic simulation using the MATLAB/Simulink Power System Toolbox.

In the year of 2013 Ram, S.K.; Das, B.B.,[7] in the study of Various electronic circuits such as inverters, choppers, cyclo-converters, SMPS used by industrial and domestic purposes are non-linear in nature, which makes the load current to be distorted, causing undesirable effects like heating, equipment damages, EMI related problems in power system. The active power filter (APF) is the best solution for eliminating the harmonics caused by the non-linear loads. This paper presents about a three-phase four-wire active power filter for power line conditioning to improve power quality in the distribution network and implementation of a digitally controlled APF. The active power filter is implemented with PWM based current controlled voltage source inverter (VSI).The switching signals for APF are generated through proposed three-level hysteresis current controller (HCC). The shunt APF system is modeled and investigated under different unbalanced non-linear load conditions using MATLAB program. The Controller Design using Hardware Description Language (VHDL or VERILOG) becomes independent of process technology. Synchronous reference frame (SRF) is used for generation of reference current. Both PI current algorithm and HCC are written in VHDL code and implemented using FPGA platform.

IV. PROBLEM IDENTIFICATION

A simple harmonic compensation strategy had been proposed for current-controlled DG unit interfacing converters. By separating the conventional proportional and multiple resonant controllers into two parallel control branches, the proposed method realizes power control and harmonic compensation without using any local nonlinear load harmonic current extraction or PoC harmonic voltage detection. Moreover, the input of the fundamental power control branch is regulated by a closed-loop power control scheme, which avoids the adoption of PLLs. The proposed power control method not providing sufficient power control even when harmonic compensation tasks are activated in the DG unit or the PoC voltage changes. Simulated and experimental results from a single-phase DG unit may be improved in future.

V. CONCLUSION AND FUTURE SCOPE

The introduced mathematical tool proposes a general alternative to calculate the instantaneous power, based on a formal definition regardless of the reference frame and phases number of the power system. This new formulation allows the estimate of the reference currents for APFs control from a geometric point of view. This is accomplished by measuring of the shape deviations (changes in the dimensions) in each component of the power tensor proposed. Besides, an active power filter can be implemented with the simulation that has been studied.

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