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A Review on Single -Phase Shunt Active Power Filter using Parabolic PWM for Current Control

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Abstract- In this paper, a single-phase active power filter with non-linear load is connected to a single-phase grid. The single-phase active control filter mitigates the harmonics of the non-linear load connected at PCC load. In order to prevent injection into the source of harmful influence, the harmonics produced by the non-linear load are directed to an active direction. The present study presents a new one-stop active control filter which can be attached to half a bridge with condensers. The two electronic power devices of the active power filter are operated by parabolic PWM with the source voltage input and load current for controlling the harmonics in the source current. The parabolic PWM is equivalent to the hysteresis controller, with the use of the hysteresis controller eliminating the source current harmonics is studied in the present review.

Keywords- Single phase grid, pulse width modulation, active filter, harmonic grid, passive filters

I. Introduction

Three functional blocks – Transmission, Generation, Distribution – are known to be the own electrical energy grid. Non-linear load harmonics, such as power converters and adjustable speed drives and some other unbalanced load in distributor networks, reduce the power output in power and distribution systems. Non-linear loads boost losses and contribute to harmonic grid distortion. This leads to numerous issues with both the power grid and linked devices with low power efficiency. The use of passive filters can minimize this harmonic distortion. The usage of conventional offsets using condensing banks and passive filters, owing to potential resonance between line induction and shunt condensers, contributes to harmonic propagation and voltage amplification. Passive filters also cannot necessarily have a total payout solution. In the last few years, multiple active filter solutions have been studied continuously as an alternative. Usually, APF consists of three single-phase inverters and pulse width (PWM) modulation and can be wired either parallel or in series to the load.(Zhang, Li, and Wang 2010)

The use of active power filters is generally recognized and adopted as a more versatile and dynamic means of power conditioning among the different choices available to boost energy efficiency. (Bhonsle and Kelkar 2011)The active power filters and active power series filters are essentially pulse width modulated (PWM) current source inverters (CSI) and voltage source inverters (VSI). Disadvantages with traditional passive filters including large scale, resonance issues, source impedance dependence, and fixed compensation the hybrid filters incorporate the productive cost of passive and reactive filters.

Most active filters are based on sensing harmonics and non-linear load reactive volt-ampere demands. And they need to be regulated in dynamic terms. The phase voltages and load currents are converted in certain active filters into α-β orthogonal amounts from which the actual and reactive power is instantaneous. The compensation currents are measured by instantaneous power and load currents. The harmonic power components of the measuring circuit are measured using high-speed filters. The dc condenser voltage control circuit changes the average voltage value to the reference value.(Yusoh 2013) Without detecting and measuring the reactive current portion of the charge, reactive power compensation is done, and the control circuit is streamlined. With the constant switching frequency, a stronger switching pattern is accomplished—the current power. An active filter based on the active and reactive current portion, which compensates for the current harmonics of positive and negative series, including the fundamental current of negative sequence, can be compensated. Therefore the device functions as an unbalanced and harmonic current equivalent. A distinction is made between the active and reactive current instantaneous component approaches and the active and reactive power instantaneous system.(Barathi et al. 2015)

Classical control theory or current control theory was the foundation for traditional controller requirement solutions. Widely applied classical PID family control modeling theory requires detailed linear mathematical models. Under differences in conditions, nonlinearity, load disturbances, etc., the PID family of controllers was unsatisfied.

II. LITERATURE REVIEW

(Kanagavel, Vairavasundaram, and Padmanaban 2020)explained about a model predictive current control (MPCC) -based single-phase shunt active power filter (SAPF) is proposed in this manuscript to improve power quality by harmonics and reactive power compensation. For the calculation of the SAPF reference current, the DC connector voltage-based PI control algorithm is employed. The MPCC monitors the latest instructions. In this manuscript, the successful control technology is illustrated by the simulation and experimentation of MATLAB under complex operating conditions with the Cyclone-IV EP4CE30F484 FPGA surface. The findings obtained from a simulation and hardware prototype illustrate perfect reference current monitoring and fantastic dynamic output with each sampling moment. The key benefits of the proposed controller are the lack of internal control loops and the modulation process.

(Qutaina and Thesis 2019) This study introduces the Shunt Active Power Filter (SAPF) safety architecture, modeling, control techniques, and enhancement of power quality (PQ) applications in the medium voltage (MV) market. The reactive power and the power factor are also balanced with SAPF to reduce the altered harmonics and transients produced by grid-tied inverter and non-linear loads, including different electronic converters. This research focuses on the implementation of numerous SAPF topologies such as two SAPF inverters at two-level and at multiple stages (basically Neutral Point Clamped-NPC inverters). The study focuses on the efficiency and implications, in particular of proportional-integer (PI) and hysteresis current controllers along with Hysteresis Current Controllers (HCC). The purpose of the analysis is to compare the various topologies and control techniques. The experiments will also show the ability of different schemes to compensate for Total Harmonic Distortion (THD), correct the power factor up to unity (DC-Link voltage, DC capacitating, and coupling inductor values), which will minimize the physical size of passive components in SAPF. In SAPF, we are looking at a few different systems to correct the power factor. In addition, the test will concentrate on the effects of SAPF in multiple operating scenarios, for example, by developing a second harmonic ratio system that improves the protection efficiency of SAPF, which also results in a real case study after collection of actual MV grid data. Real case analysis will also occur. The program package MATLAB/SIMULINK is used to run the analysis, compare the findings, and reveal the results.

(Ray 2018) With the use of non-linear systems, the issue of the power quality in the power system is increased. The harmonic content of the source current increased because of the uses of non-linear equipment like power electronic converters. As a consequence, the losses, volatility and low voltage waveform are rising. We use filters in order to minimize harmonics and to compensate for reactive power. The power system uses multiple filters. Restricted compensation is granted by passive filters, while variable compensation should be used for active filters. A shunt active filter has been tailored to this text by a control unit dependent on Variable Leaky Least Mean Square (VLLMS). The adaptive controller can offset harmonic currents, power factor and nonlinear unbalance of load. DC condenser stress with the PI controllers and the self-loading mechanism has been regulated at a desired level. Simulation and testing have tested the principle of the adaptive controller for the shunting active filter.

(Magdum and Patil 2017) This paper introduces the creation of a single step, non-linear, active power filter. A brief comparative approach was proposed for removing the harmonics, instant p-q single-phase, and d-q synchronous reference frame method. The results of the harmonics extraction technique are generated by the asynchronous d-q single-phase frame reference method (APF). An imaginary vector is considered and accomplished by including a /2 delay in the initial signal in order to develop a d-q transition for the one-phase method. This paper mentions in-depth the real-time implementation of the single-phase d-q frame-based shunt APF method. The output of the APF shunt is assessed to compensate for the harmonic load current under sinusoidal conditions and skewed voltage supply conditions. The experimental research is explored in Simulation and Digital Signal Controller (DSC).

(Anjana and Maya 2016) Harmonic presence, voltage, and fluctuations in frequency deteriorate device performance. Different factors of the power grid influence the efficiency of the power supplied. Due to their fast switching and non-linear features, the system introduces much of the power quality problems by Power Electronics types of equipment. Power quality problems become particularly relevant in market competition due to the use of more responsive devices. Owing to the integrated compensation and often the lack of implemented legislation, this delicate equipment can cause further issues. As a view to the stable and continuous operation of the Power Grid, the increase in power efficiency is becoming increasingly necessary. By using filters and compensators, power efficiency can be increased. Active control filters are used for enhancing power efficiency. The Simulink Shunt Active filter model for improving power efficiency was introduced in this article.

Table 1: Some noteworthy contributions of the researchers

Author	Title	Objective of the study
(Yusof et al. 2019)	Single-phase Shunt Active Power Filter by Using Piecewise Linear Look-up Table Controller	The design and usefulness of piecewise linear look-up table based single input Fuzzy Logic controller as the compensator of single-phase shunt active power filter to overcome the source current harmonic problems.
(Samikannu et al. 2018)	Design and Development of Shunt Active Filter Using MATLAB for Minimization of Harmonics	In this work as introduction different power quality problems, harmonics and their mitigation techniques/filters are presented and discussed. Between the different ways to minimize/eliminate harmonics active power filters are most Prominent one.

(Soomro, Omran, and Alswed 2015)	Design of a shunt active power filter to mitigate the harmonics caused by nonlinear loads	The design and application of three-phase shunt active power filter (SAPF) are studied by using p-q theory to mitigate the harmonics which are created by nonlinear loads.
(Saswat 2014)	Study of Single Phase Shunt Active Power Filter	Hybrid Active Power Filter (HAPF) has been proposed to overcome the disadvantages of APF and HPF. It is a combined system of HPF and APF.
(Hamzah and Hamzah 2009)	Single-Phase Shunt Active Power Filter Using Single-switch Incorporating Boost Circuit	An active current wave-shaping technique is proposed to mitigate the distortion current by injecting equal but opposite current to shape the pulsating nature of the supply current to a sinusoidal form and in- time phase with the supply voltage.

III. CONCLUSION

The use of single and three phases' non-linear loads producing harmonic disruptions is sharply growing in current electric power supply systems. For a 3 phase load, a MATLAB simulation will be shown. And a single-phase shunt active filter will be used in the hardware model.The active power filter, which is related to the PCC, helps to minimize non-linear load harmonics. The active power filter offsets the skewed source current signal that diverts the harmonic from the non-linear load that protects the source against disruption.

In order to measure the current magnitude of the PI controller used at the DC voltage controller, adaptive controllers or flushing logic controllers can be substituted for a more harmonic reduction on the grid. Passive filters may be used in conjunction with active power filters to further reduce harmonics, thereby reducing harmonics below 1 percent.

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