A Review on SAPF for Harmonic Compensation in Grid-Connected Applications

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Abstract: Researchers discovered that the methods used to lessen the impact of harmonics in the source current varied widely across loads. Because of nonlinear loads, there is an uncertainty problem with eliminating harmonics. Fortunately, power quality and harmonic concerns are both amenable to elimination by use of filters. However, providing dynamic performance under varying loading circumstances at a reasonable cost is prohibitive with these filters. This research aims to achieve this goal by maximizing voltage stability under varying loads while minimizing source current harmonics. To improve power quality, harmonic reduction, and reactive power compensation are all topics we examine in this review paper. These days, people are primarily worried about power quality issues. In this research, we examine the characteristics, working principle, implementation, and performance of many different kinds of existing phase synchronization algorithms that have been employed to manage operation of SAPF. This evaluation has the ability to act as a manual and source of data for deciding which method of synchronising SAPF with the linked power system is optimal.

Keywords: active filter; control technique; harmonics mitigation; phase synchronization; power quality issues

I. INTRODUCTION

While several devices have been suggested for use as PQI devices throughout the years, each has its own set of limitations, making further research into the field essential. Multifunctional DGs are one creative solution to the power quality problem, despite the fact that integrating power electronic based converters and nonlinear loads may reduce power quality. [1] With the microgrid, we can fix some of the system's problems and make the grid more secure and reliable. Since their introduction in the 1990s, microgrids have received increasing interest from academics. It contains distinct characteristics that will improve power quality, such as the incorporation of several DG units of diverse natures to boost overall system dependability. Power electronics-based converters are utilised by the majority of DG units; therefore, this kind of energy source might be employed to enhance power quality. [2] Although each power electronics-based converter used in microgrids performs some of the same duties as a regular converter, the power quality of the grid as a whole might improve. [3] There have been a lot of research done on the issue of distributed power system power quality, but most of them have only looked at one aspect of the problem. [4]

A. Active Power Filters (APF)

Active power filters are a good option for tuned passive filters since their effectiveness is significantly reliant on the tuned factor, quality factor, and source equivalent impedance. Active power filters (APFs) were created to address the shortcomings of passive power filters. APFs can eliminate harmonics, enhance power factor, adjust for unbalances and flicker, as well as adjust voltage. With various topologies and control techniques, APFs have been deployed as PQI devices. There are some extensive comparisons between different APFs and their uses, however the most of the analyses are based on topology. Shunt active power filters as well as series active power filters are the two types of active power filters. [5]

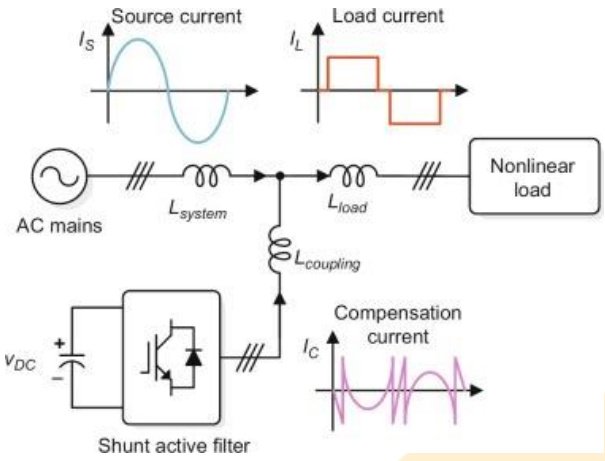

Figure 1: Active Power Filter

B. Shunt active power filter

It substitutes for current harmonics by infusing a harmonic current with almost the same magnitude as the harmonic current but 180 degrees phase difference. As a result, harmonic current is adjusted, therefore grid current is almost sinusoidal and phase-locked to the source. Additionally, if correct control mechanisms are applied, an active power filter can also be used to compensate reactive power. A parallel active power filter having nonlinear load appears to be a linear load from the grid's perspective.[6]

As demonstrated, APF compensates for nonlinear load current by infusing the same nonlinear current from the grid that the load consumes, resulting in a sinusoidal grid current. Novel control methods for shunt active power filters, as well as new applications for shunt APFs, are the focus of current research in this topic. In, a more in-depth examination of the main topologies of shunt active power filters is carried out.[7][8]

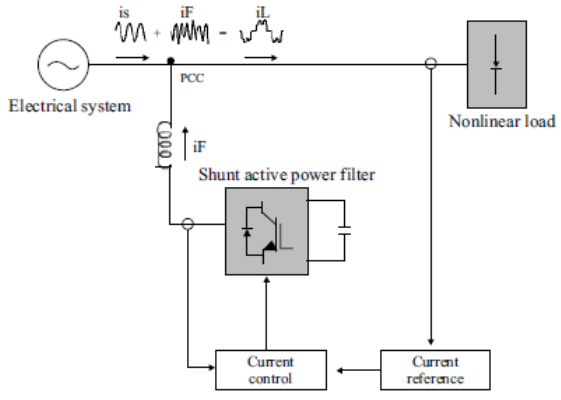

Figure 2: Block diagram of SAPF

II. LITERATURE REVIEW

(Hariyaliyan, 2020) [1] The most effective solution for nonlinear loads, current harmonics, as well as power quality issues is a shunt active power filter. Because APF topologies for harmonic compensation rely on a large number of high-power rating components, they are inefficient. Topologies that combine low-power ratings and hybrid topologies APF with passive filters is being used to lower the voltage source inverter's power rating. A transformer with a large number of passive components is used in hybrid APF topologies for high-power rating systems. A novel four-switch two-leg VSI topology for a three-phase SAPF is described in this project in order to reduce overall costs and space. A two-arm bridge structure, 4 switches, coupling inductors, and sets of LC PFs are all part of the suggested topology.

(Manikanta et al., 2020) [2] When we talk about power transmission and distribution, the term "power quality" comes up frequently. When compared to other renewable energy sources, solar is the most dominating and most accessible all of the time. When solar energy is integrated into the grid, the system's power quality suffers. It increases a system's power quality. In this study, researchers will incorporate solar energy into the grid to enhance the system's power quality. PV array, boost converter, inverter, PI controller, as well as Fuzzy Controller will all be used in this project. The Shunt Active Power Filter was created to filter harmonics and compensate for reactive power.

(Rameshkumar & Indragandhi, 2020) [3] In Single-Phase Shunt Active Power Filter, this manuscript provides a comprehensive overview of commonly utilized reference current extraction techniques (SAPF). The use of a single-phase shunt active filter in commercial as well as educational buildings has expanded significantly in recent years in order to enhance power performance and maintain customer satisfaction. The removal of harmonic current is crucial to the performance of a shunt active power filter. Several reference current extraction strategies, such as the PI control algorithm, PQ Theory, DQ Theory, and others, are explored in order to duplicate the precise inverse image of harmonic currents. Furthermore, the key

benefits and drawbacks of power filters are contrasted. Finally, the DC-Link capacitor voltage as well as capacitance rating, as well as the SAPF filter inductance, were thoroughly examined.

(Keerthi et al., 2020) [4] In recent years, the term power quality (PQ) has gotten a lot of attention from both the distribution and consumer sides. The growing use of power electronic devices in grid-tied applications, uninterruptible power supply (UPS), as well as motor drive applications, among other things, simplifies control technology and makes systems more durable and versatile. However, these gadgets damage the electrical system by injecting current harmonics into the line. It also consumes more reactive power, causing the system to become unbalanced. Passive filtering techniques (inductors and capacitors) were initially utilized to mitigate PQ issues. Researchers are always looking for new and more cost-effective ways to increase system PQ. Shunt active power filter (SAPF) has been one of the better options for improving power quality in grid-connected systems by balancing harmonic currents as well as other reactive power issues.

(Khan, 2019) [5] Traditional electrical power networks have been gradually evolving into smart grids as well as emerging as next-generation power technology in recent years. The use of power electronics is a critical component of these changes. Recent advances in power electronics have accelerated the integration of renewable energy sources, energy storage, as well as modern loads into the hybrid microgrid linked with the smart grid. However, it poses a number of issues in terms of dependability and resilience, as well as power quality and cost. To address these issues, sophisticated control strategies as well as converter architecture will be necessary. Modern control techniques and circuit topologies for grid-connected systems in hybrid-microgrid applications are presented in this thesis. In AC/DC power conversion, system parameter fluctuations and unpredictable disturbances are crucial for accomplishing control objectives.

(Suresh & Ramesh, 2019) [6] For improving current and voltage profiles, the SPV interfaced grid system with battery storage unit, bidirectional VSI interconnected shunt active filter, as well as an adaptive Proportional Integral (PI) controller is used. Using a diode rectifier or a non-linear load, the p-q theory is a commonly used technique for extracting the basic fundamental current harmonic components from a polluted or impacted power source. It is a time domain model that can be used to both 3P3W and 3P4W, according to the core notions of reactive power (IRP) theory. The control technique known as instantaneous real and reactive power theory, or p-q theory, was first developed for three phase three wire systems and later expanded to three phase four wire systems. This system works in both the steady and dynamic states.

(Niranjana et al., 2018) [7] The non-linear properties and quick switching of power electronic gear cause serious problems in power systems. Because of sensitive technology, power quality issues are getting more serious. The proposed PQ theory is utilized to calculate the reference compensating currents that must be injected into the network at non-linear load linked points. Comparing the reference compensating currents produced from PQ theory with compensator currents provides a switching method for the compensator. To satisfy non-linear loads, compensating current must be injected to ensure reactive power as well as bring the source current waveform to a sinusoidal shape. Shunt active power filters have been used to reduce current harmonics and compensate for reactive power by emulating three phase four wire and three phase three wire systems. As a result, the power factor has already been enhanced by aligning the source voltage and current.

(Patil et al., 2018) [8] Every citizen's high level of living, as well as any country's progress, is primarily dependent on the availability of high-quality, abundant electric power. With the growth of science and technology, the demand for electric power has risen at an exponential rate in recent years. The operation of many consumer gadgets necessitates the use of high-quality power on a constant basis. The quality of power provided to end-user equipment has a significant impact on its performance. As a result, these issues should be addressed in order to improve the

consumer equipment's performance as well as the system's overall performance. The word "power quality" has gained a lot of traction in the power industry, and it's something that both the electric power supply business and the end customers are worried about. Harmonics are polluting the power distribution system as more nonlinear devices are used in residential and industrial applications. Passive Filters (PF), Active Power Filters (APF), as well as hybrid filters can all be used to achieve harmonic compensation (HPF).

III. CONCLUSION

Modern phase synchronisation approaches for connecting SAPF to the electrical grid have been researched and described in depth in this book. In this article, we give a conceptual model that shows the overall SAPF working principle and how the synchronisation algorithm interacts with other algorithms in the SAPF control system. Active power filters may be configured in a variety of ways to address harmonic current, reactive power, neutral current, and unbalance current in a harmonic load. Literature analysis has shown that certain freshly suggested strategies outperform more established ones. Controllers such as PI controller, PID controller, FIS Controller can be used for harmonics reduction and low THD in the power distribution system.

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