DESIGN AND ANALYSIS OF SHUNT ACTUVE POWER FILTER TO ENHANCE POWER QUALITY

MODUGU SOWMYA[1] |SIVA PRSAD[2] B.SHIVAJI[3]

[1]Pg Scholar, Dept of EPS, Kodada Institute of Technology & Science for Women-Kodad, Telangana.

[2] Assistant Professor, Dept of EEE, Kodada Institute of Technology & Science for Women-Kodad,Telangana.

[3]Assoc Professor& HOD,Dept of EEE, Kodada Institute of Technology & Science for Women-Kodad,Telangana.

ABSTRACT: This paper describes a new method for generating reference current for a Shunt Active Power Filter (SAPF) based on the Savitzky-Golay Filter (SGF). Despite their ability to reduce music in lattice disturbing influences and nonlinear burden situations, the standard and current SAPF have many display flaws, including computational complexity, normal ability to sort, and drowsy distinctive reaction. The suggested SAPF in light of SGF is capable of providing a significant reference current that is freed from music, which may finally enhance the overall consonant profile and execution when compared to contemporary SAPFs. Furthermore, by storing the important information of the sign, an SGF-based Stage Locked Circle (PLL) is able to organize the damaged cross section voltages in a clear and understandable manner. In contrast to the traditional PLLs used in the SAPFs, it does not result in any output phase delays or distortions. The disclosures cover the primary accomplishments of this special duplication, and the evaluation of execution is completed in close proximity to other SAPFs. This includes a notable enhancement of the transient performance and harmonic characteristics.

KEYWORDS: SHUNT ACTIVE FILTER, PLL, POWER QUALITY, TRANSIENT.

I.INTRODUCTION: The presence of high current music in power conveyance frameworks is a major contributor to the deterioration of force quality due to the widespread use of nonlinear loads. At this stage, a great deal of study has begun. Consonant streams in the electrical association basically reduce the overall system's performance and lead to other associated problems, such as equipment overheating, basic device malfunctions, and capacitor blowing. Therefore, it is necessary to install mitigating devices in order to contain and limit harmonic currents from nonlinear loads. The Shunt Dynamic Power Channel (SAPF), one of the most amazing lightning progressions, has been widely used to reduce current noises. A accurate reference current enables the SAPF to effectively remove harmonic problems [2, 3]. Although there have been several methods proposed in the literature for generating reference current [4–6], the momentary dynamic/receptive power (PQ) hypothesis [7–10] and the simultaneous reference edge (SRF) hypothesis continue to be the most popular because of their ease of implementation and practical simplicity. In contrast to other complex methods, such as the Fast Fourier Change and artificial neural networks], SRF and PQ control systems are generally simple and straightforward to implement. Nevertheless, a few limitations restrict their use in existing applications.

One significant drawback of using a conventional Stage Locked Circle (PLL) in the SRF approach is that it must be used carefully if the source voltages are distorted or unbalanced. However, standard PLL fails when handling lattice voltages that are significantly distorted. The filtering capacity and the transitory reaction of the regulator are the two main causes of this. Therefore, transient responsiveness and filtration capability have been the main focus of SRF-PLL performance enhancement research [5]. A Moving Average Filter (MAF) was suggested in as a substitute for the traditional Low Pass Filter (LPF) in the upgraded PLL. It used a pre-separating stage to make the music easier to get rid of. However, it displayed a slower transitory reaction when stage or recurrence was changed [20]. This flaw is addressed by EPMAF-PLL, another high level PLL that focused on the transient reaction as opposed to [19]. The Kalman Filter (KF) was used instead of the LPF in SRF-PLL, following a methodology similar to that of.

The main drawback of this PLL is that proper presentation depends on precisely aligned weighing capabilities, which may require AI techniques with a high processing burden. An LPF is used in place of a comb filter in another sophisticated PLL. Additionally, it achieved widespread execution and great primary straightforwardness. To control DC Offset (DO) and Symphonious between Sounds (HIH) in network voltage, a high-level HIHDO-PLL is suggested. Under grid imbalance and disturbance, this PLL did reasonably well. Naturally, even though PQ-based SAPF eliminates the requirement for PLL, it requires additional voltage rules and computational analysis of dynamic and responsive power, increasing the built controller's handling complexity. Furthermore, mathematical channels, either High-Pass Channels (HPF) or Low Pass Channels (LPF), are still used in both the PQ and SRF hypothesis methods to determine their precise power and current components for reference current generation.

In any case, LPF is preferred due to its superior symphonious dropping effects. However, as discussed in [5], when the intentional essential component has a large number of waves, mathematical LPF is unable to provide a reliable ID of the major section. Consequently, much of the reference current produced in this way is inaccurate. Furthermore, it is challenging to compute the filter order and cut-off frequency balance of a conventional LPF because it involves numerous trigonometric computations. The aforementioned claims require a control method to successfully stop the incorporation of traditional LPFs into SAPFs. Experts have recently expressed a great deal of interest in this area and suggested a variety of control mechanisms for SAPF to consider in order improving its presentation. A few important issues with SAPFs control are discussed. The control suggested employed a KF-based weighting capability regulator for both symphonious end and stage assessment. The results were positive, and the regulator successfully avoided utilizing traditional LPFs. Regardless, the weighting capacities of the regulator should not be completely fixed and physically adjusted to achieve exact symphonious disposal. In general, KFs anticipate that structure conditions or discernment models are both straight. Conversely, nonlinearities are common across the distribution system [10].

This could lead to an imprecise estimation or filtering of the KF. Furthermore, the performance of the KF-based controller was not clearly compared to other SAPFs in the manuscript. KFs are known to have a very limited capacity for filtration. To extract the basic component from the load current, a Wiener filter, sometimes called a Finite Impulse Response (FIR) filter, was added to the SAPF of the used controller. In any event, the advanced weight capabilities, which considerably lessen the regulator's transient response during trial execution, were predicted by the control to be determined by an iterative cycle. Once more, no proof was offered that its better performance could be directly compared to other SAPFs. Additionally, because the controller relied on traditional LPFs to minimize current harmonics, its ability to eliminate harmonics was restricted. The framework employed a MAF to give consonant relief and remove essential components from the shunt compensator. While MAF uses a convolution interaction like SGF, it cannot hold the important information of a sign. As a result, it could cause stage mutilations in the outcome signal. A regulator based on brush channels is used in both the symphonious end and the stage evaluation. There is still much space for improvement, especially in terms of how well the filters can lower current harmonics, even if these controllers usually produce better results than the traditional SAPF.

II.PROPOSED SYSTEM: SGF's ability to smooth and filter data makes it a great FIR filter. The most noteworthy aspect of SGF is that it not only eliminates noise and harmonics from signals but also maintains the essential information of those signals unchanged. Among other FIR channels, the MAF and Wiener channels are deficient in include. Because the sinusoidal display of the organization voltage and current completes the presentation profile of a SAPF, this intelligent SGF component is particularly crucial for system applications. The linear least squares method is used to fit subsets of nearby data points in order to accomplish SGF's filtration in convolution. SGF has a clear filtration capacity advantage over other channels thanks to the convolution cycle. SGF's lack of predetermined weight capabilities also makes its design and capabilities numerically simple. The main goal of SGF is to identify the intermediate points and select the polynomial degree that best fits the harmonic, ripple, or other noise components caused by nonlinear loads or imbalanced grid networks. The suggested SGF-based SAPF's topology configuration is shown in the figure. 1.

The SAPF is performed between the three-stage voltage source and the nonlinear weight at the Reason Likewise Coupling (PCC). A current is injected by the suggested framework through the PCC and back into the orchestral polluted framework during the activity. This continuous kills the consonant streams of the nonlinear weight and further enhances the symphonious profile of the network current. This current also controls the inverter's DC charging current (idc) to lower switching losses. This paper presents a unique SGF-based SAPF topology that intends to greatly outperform a standard SAPF in the presence of grid disturbances and nonlinear loads. This article uses SGF-based PLL to further enhance SAPF's consonant profile and execution, despite the fact that the reference current age is the main focus.

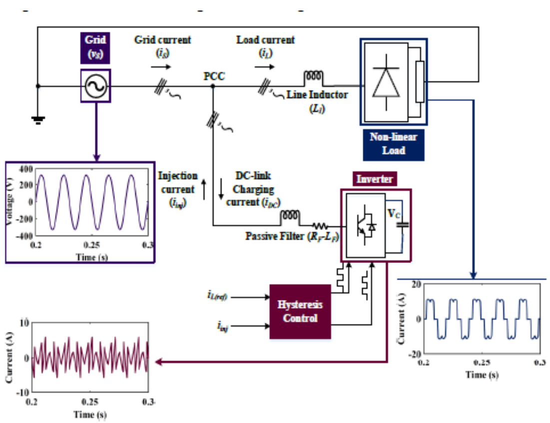


Fig. 1. Topology configuration of the proposed SAPF.

The SGF has a restricted drive reaction and is a FIR channel. That is, a weighted moving average. SGF can be represented as follows in the discrete-time region (k) and the persistent time space (t):

$$\bar{v}(t) = \int_{t-T_W}^{t} v(\tau)\,d\tau \qquad (1)$$

$$\bar{v}(k) = \sum_{n=0}^{N} h(n)v(k-n) \qquad (2)$$

While (n) tends to the SGF's drive response, vv and $v\bar{v}$ separately tend to the data and result signals. The length of the frame is indicated by the letter Tw in SGF. The channel's characteristics and the polynomial solicitation or channel demand N are displayed in an SGF limit. Least squares polynomial approximations are used to perform SGF's responsibilities. In other words, the main purpose of SGF is to identify the 2Tw + 1 intermediate points at Tw = 0 in order to reveal the polynomial degree or filter order N that most closely resembles the target data. The definition of the SGF polynomial is as follows:

$$p(k) = \sum_{n=0}^{N} c_n k^n \qquad (3)$$

Where c_n denotes the coefficient of the polynomial that fits the best. (1) and (2) can be used to accomplish the SGF filter's s-domain and z-domain transfer function [33]:

$$G_{SGF}(s) = \frac{\bar{v}(s)}{v(s)} = 1 - (1 - e^{-T_w s})G(s) \qquad (4)$$

$$G_{SGF}(z) = \frac{\bar{v}(z)}{v(z)} = \sum_{n=0}^{N} z^{-n} = 1 - (1 - z^{-1})^{N+1}G(z) \qquad (5)$$

The transfer functions of an additional FIR filter in the s- and z-domains are denoted as G(s) and G(z), respectively. The following method can be used to calculate the SGF's frequency response using (4):

$$G_{SGF}(j\omega) = 1 - \left[\sin\left(\frac{\omega T_w}{2}\right) \times \left(\frac{\omega T_w}{2}\right)\right] G(j\omega) \qquad (6)$$

As demonstrated in (6), the SGF filter has a symmetric impulse response of h(n) = h(n) and a real-valued frequency response. Because it avoids stage disturbance in network frameworks, the zero-stage channel trademark may thus be added to SGF and is highly feasible for application within SAPF. The next subsections address parameter selection and the suggested filter's performance. To choose the improved value of edge length (Tw) and channel request (N), the recurrence area conduct of SGF is examined. Accordingly, SGF's motivation and recurrence reactions are calculated independently for 0 and various upsides of Tw and N. To determine the passband, the recurrence is examined at the point where 20log10(ej) is "3 dB falling" of the 0 dB value and the channel gain is at =0. The picture shows the measurements made using filters of even polynomial orders N (Tw = 3,...,13) and (Tw = 25,50,100,200). As shown in Fig. 2, when N2Tw occurs, the cut-off frequency (fc) varies almost linearly with N while the slope correlates negatively with Tw. However, the symmetric portion of the bend corresponds with the constraint of plausible readings of N when Tw is bigger, as in the four tests Tw = 25, 50, 100, and 200. Consequently, a direct relevance persists throughout a larger range of N. It is clear that when the number of TTww is increased while the number of N is decreased, very narrow pass bands are produced, which would be useless unless the signal elements were massively oversampled. This is the case for Tw = 25, 50, 100, 200, and N = 2, where the deviation in assessing the noticed cut-off recurrence is in 8%. 7) offers a detailed analysis of SGF's behavior with more accurate projections for 10Tw25 and N finely controlled. By default, the SGF channel is appropriate for N factors up to about 35.

$$f_c = \frac{N+1}{3.2T_w - 2} \tag{7}$$

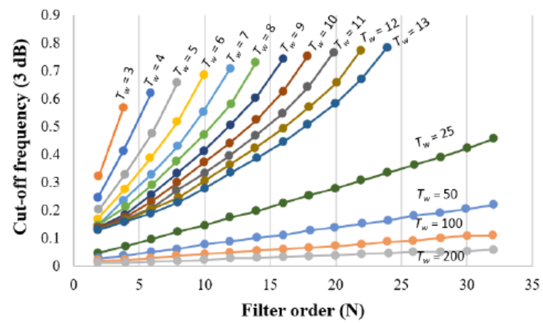


Fig. 2. Impulse response of SGF at different values of T_w, N, and 3 dB cut-off frequency.

Figure 3 makes it evident that, in contrast to SGF and MAF, the other two channels—Several Second-Request Summed Up Integrators (MSOGI) and Brush—execute constriction normally, especially for low-request sounds. This display advantage is conceivable since both SGF and MAF use the convolution cycle. The Bode plot illustrates how the filters attempted to block the high-frequency harmonics by adding notches at the third, fifth, and seventh frequencies. Due to the preset number of scores, MSOGI's presentation was the most dreadfully terrible in this way. Contrary to expectations, the brush channel outperforms MSOGI since it was given extra scores to prevent unwanted music. In any event, the show currently falls short in terms of what distinguishes MAF and the suggested SGF. Even though their performances are nearly same, SGF is weaker than MAF. Furthermore, as will be shown and described in the next section, MAF's superior noise reduction capabilities do not identify transient signal jumps. Therefore, it is possible to conclude that the suggested SGF has the most realistic ability to reject music. To totally remove harmonics, many notches centered at integer multiples of fc are added.

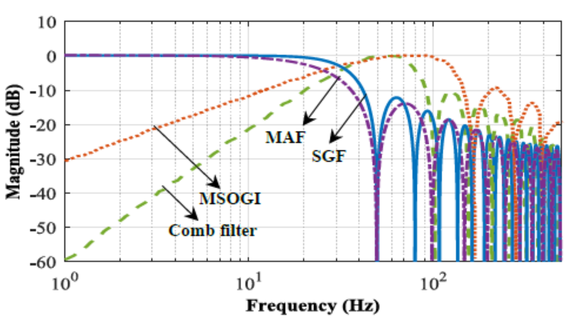


Fig. 3. Bode plot of SGF, Comb filter, MSOGI, and MAF. [34]

There are two primary components to the planned SAPF's overall control. Utilizing SGF-based PLL to synchronize source voltages with the optimal reference stages is demonstrated in the crucial region. The second section also covers the SGF-based SAPF for creating reference currents or extracting harmonics. A. PLL based on SGF

As seen in Fig. 4, the suggested control aims to substitute an SGF-based PLL for the traditional PLL in SAPF. In extraordinary matrix settings, the PLL's primary function is to maintain the stage arrangement of the framework voltage and current. It is also responsible for reducing any disruptions brought on by the lattice side voltage and adjusting the network current. However, traditional PLL is significantly harmed by the usage of conventional LPF in the PLL. As mentioned before, LPF has poor filtration capabilities and a delayed transient response. As a result, SGF, which has the following advantageous qualities, has replaced the traditional LPF in the typical PLL: 1. SGF is a zero-work channel that does not allow the PLL's result signal to readily twist. 2.

It can actually channel more effectively than LPF because it makes use of the convolution cycle. By retaining important information about a sign, the SGF performs better than the MAF, which employs a convolution cycle in a similar manner. It outperforms both regular PLL and MAF-PLL under network annoyances. 3. SGF is more appropriate for usage in PLL since FIR channels outperform IIR channels, such as the Kalman Channel, for progressively matrix applications. 4. In contrast to other channels like Kalman and Wiener, which necessitate careful adjustment of the weight abilities, it should not be concerned with any weight capacities to function admirably. The SGF can efficiently remove any disruptions when the information signal passes through the regulator cycle and is used in the PLL stage recognition step. The three-stage input voltages of the SGF-PLL can be handled in the discrete-time domain.

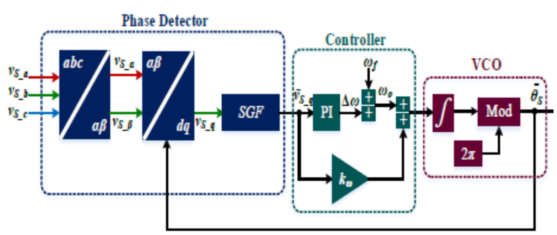


Fig. 4. Schematic block diagram of SGF-PLL.

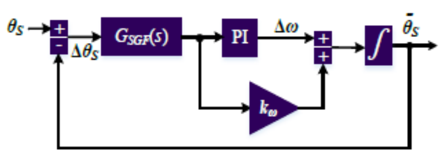
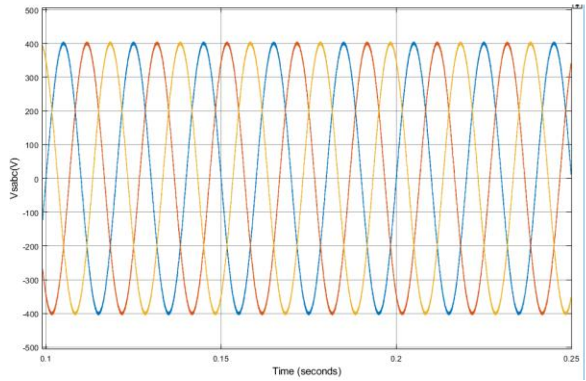
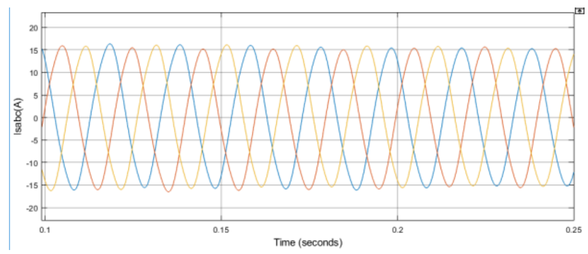


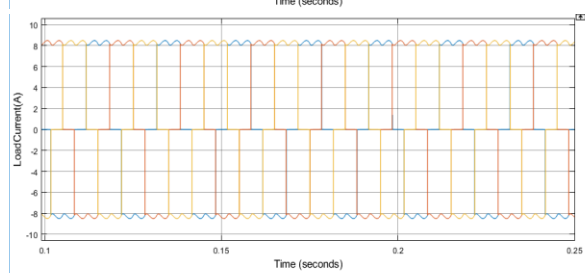
Fig. 5. SGF-PLL small-signal model.

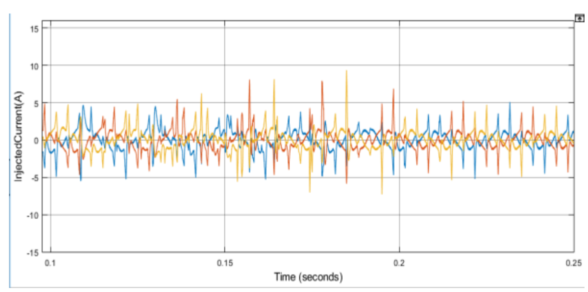
IIII. SIMULATION RESULTS

CASE_1

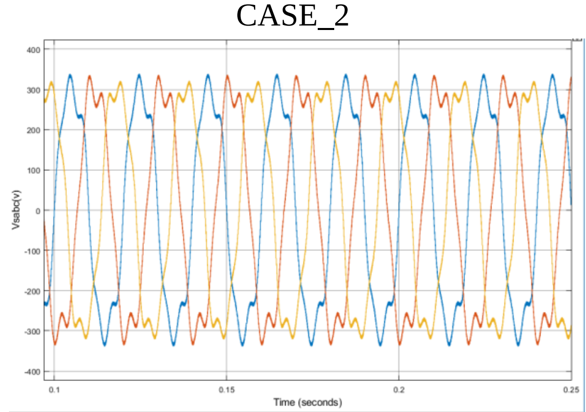


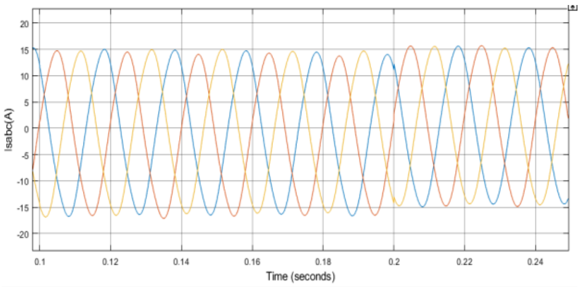


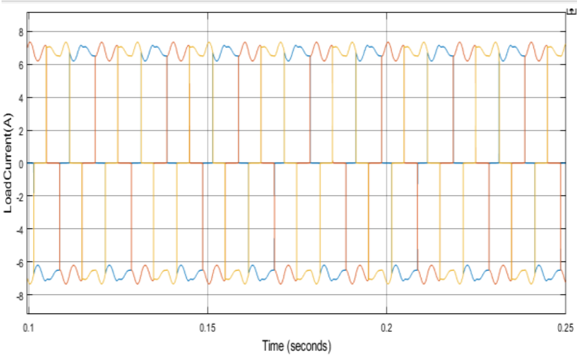


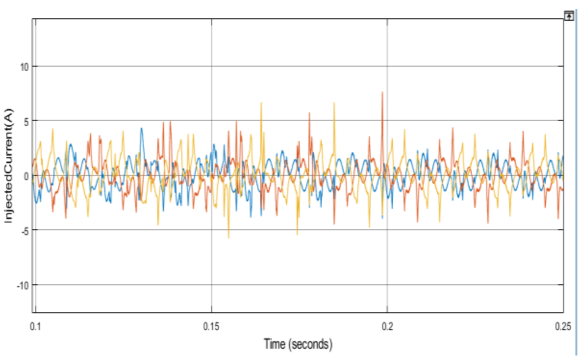


CASE_2

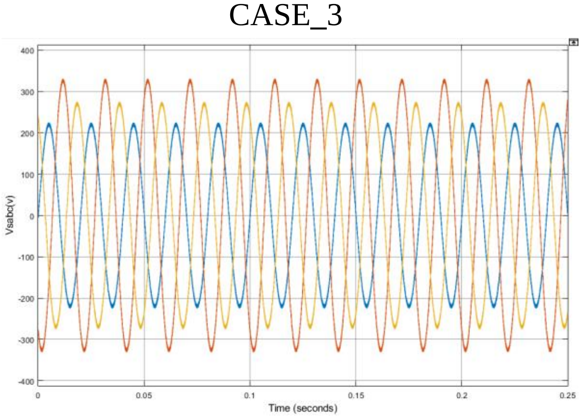


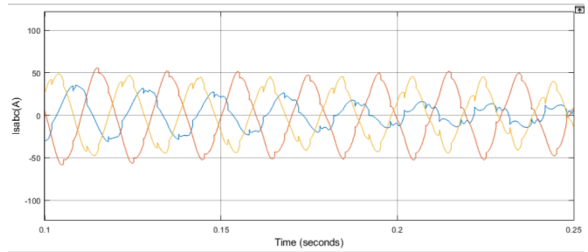


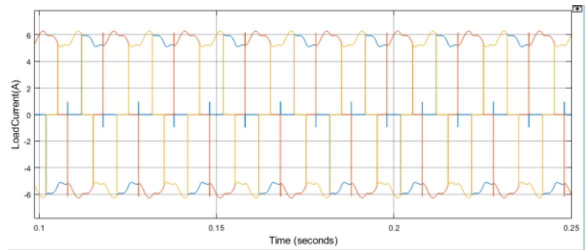


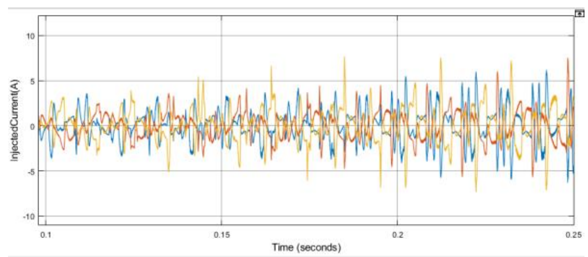


CASE_3









IV.CONCLUSION

This paper proposes a reference current generation approach based on SGF for a SAPF system. The proposed method generates the reference current by accurately eliminating harmonics under both static and dynamic grid and load conditions. The performance of the proposed SGF-based SAPF solution has been thoroughly investigated and compared with the latest and conventional SAPF techniques. A crucial confirmation of the theoretical justification for SGF's superiority over alternative filters is provided by the frequency response using Bode Plot and transfer functions. Furthermore, the simulation and experimental results demonstrate the role of SGF in the PLL, reference current generation, and SAPF's overall performance.The SGF-based SAPF technique obtained the lowest THD across three different case scenarios, according to the THD spectrum comparison analysis. The lower THD values for mitigated supply currents demonstrate the advantages of the suggested SGF technique, particularly when functioning with less-than-ideal utility voltage settings. Furthermore, the comparative performance analysis demonstrated that the SGF-based SAPF had attained structural simplicity through the use of a single control structure, fewer passive components, and less computing and mathematical processes. The experimental results demonstrate the effectiveness of the SGF-based control algorithm in terms of reduced THD in source currents, slower response times under different loading scenarios, and less time spent settling under transient conditions like frequency and phase jumps.

V.REFERENCES: [1] M. A. Mansor, K. Hasan, M. M. Othman, S. Z. M. Noor, and I. Musirin, “Construction and Performance Investigation of Three-Phase Solar PV and Battery Energy Storage System Integrated UPQC,” IEEE Access, vol. 8, pp. 103511–103538, 2020.

[2] Y. Hoon, M. A. M. Radzi, M. K. Hassan, N. F. Mailah, and N. I. A. Wahab, “A simplified synchronous reference frame for indirect current controlled three-level inverter-based shunt active power filters,” J. Power Electron., vol. 16, no. 5, pp. 1964–1980, Sep. 2016.

[3] A. Bhattacharya and C. Chakraborty, “A shunt active power filter with enhanced performance using ANN-based predictive and adaptive controllers,” IEEE Trans. Ind. Electron., vol. 58, no. 2, pp. 421–428, 2011.

[4] T. C. Green and J. H. Marks, “Active power filter control using neural network technologies,” IEE Proceedings-Electric Power Appl., vol. 152, no. 2, pp. 369–381, 2005.

[5] Y. Hoon, M. A. M. Radzi, M. K. Hassan, and N. F. Mailah, “Operation of Three-Level Inverter-Based Shunt Active Power Filter under Nonideal Grid Voltage Conditions with Dual Fundamental Component Extraction,” IEEE Trans. Power Electron., vol. 33, no. 9, pp. 7558–7570, 2018.

[6] R. Kumar and H. O. Bansal, “Shunt active power filter: Current status of control techniques and its integration to renewable energy sources,” Sustain. Cities Soc., vol. 42, no. July, pp. 574–592, 2018.

[7] H. Akagi, “Trends in Active Power Line Conditioners,” IEEE Trans. Power Electron., vol. 9, no. 3, pp. 263–268, 1994.

[8] S. Jiao, K. R. Ramachandran Potti, K. Rajashekara, and S. K. Pramanick, “A Novel DROGI-Based Detection Scheme for Power Quality Improvement Using Four-Leg Converter under Unbalanced Loads,” IEEE Trans. Ind. Appl., vol. 56, no. 1, pp. 815–825, 2020.

[9] N. Eskandarian, Y. A. Beromi, and S. Farhangi, “Improvement of dynamic behavior of shunt active power filter using fuzzy instantaneous power theory,” J. Power Electron., vol. 14, no. 6, pp. 1303–1313, 2014.

[10] S. T. Meraj et al., “A filter less improved control scheme for active/reactive energy management in fuel cell integrated grid system with harmonic reduction ability,” Appl. Energy, vol. 312, pp. 118784–118801, Apr. 2022.