A Survey on hybrid active power filter for power quality improvement with different Controller

Ravindra Kailas Date[1], Dr. Prabodh Khampariya[2]

[1]M. Tech Scholar, Department of EE, School of Engineering, SSSUTMS, Sehore (India)

[2]Associate Professor, Department of EE, School of Engineering, SSSUTMS, Sehore (India)

Abstract

Shunt active power filters (SAPFs) implemented without harmonic detection schemes are susceptible to sudden load variations. This paper proposes a robust control strategy to reduce this drawback. In this strategy, the dc-link voltage is regulated by a hybrid control technique combining a standard proportional–integral PI and a sliding-mode (SM) controllers. The SM scheme continuously determines the gains of the PI controller based on the control loop error and its derivative. The chattering due to the SM scheme is reduced by a transition rule that fixes the controller gains when steady-state condition is reached. This controller is termed as dual-sliding-mode-proportional–integral. The phase currents of the power grid are indirectly regulated by double-sequence controllers with two degrees of freedom, where the internal model principle is employed to avoid reference frame transformation.

Keywords:- sliding mode controller with PI Dual sliding mode controller with PI, Nonlinear load, shunt active power filter.

Introduction

Electrical power quality has been a developing concern because of the proliferation of the nonlinear loads, which causes significant increase of line losses, instability and voltage distortion [1]. With injection of harmonic current into the system, those nonlinear loads additionally motive low electricity component.

The ensuing unbalanced current adversely affects each component inside the energy system and equipment. This outcomes in terrible power aspect, increased losses, excessive neutral currents and reduction in standard efficiency.

Customarily, passive power filters have been utilized as a remunerating gadget, to repay mutilation produced by consistent non-straight loads. These filters [2] are intended to give a low impedance way to harmonics and keeping up great power quality with a most straightforward structure and ease. Notwithstanding, latent filters have a few faults like mistuning, reverberation, reliance on the states of the power supply system and huge estimations of detached segment that prompting cumbersome usage. For astounding power necessities, various topologies of active filters for example APF associated in arrangement or in parallel (arrangement active filters and shunt active filters) to the nonlinear loads with the point of improving voltage or current bending. These filters are the most broadly utilized arrangement, as they efficiently dispose of current contortion and the reactive power created by non-straight loads.

1.1 POWER SYSTEM HARMONICS

Power system harmonics are whole number products of the basic power system recurrence. Power system harmonics are made by non-straight gadgets associated with the power system. Harmonics are voltage and current frequencies riding over the ordinary sinusoidal voltage and current waveforms. The nearness of harmonics (both current and voltage) is seen as 'contamination' influencing the activity of power systems.

The harmonics created by the most well-known non-linear loads have the accompanying properties:

• Lower request harmonics will in general overwhelm in adequacy

• If the waveform has half-wave symmetry there are no even harmonics

• Harmonic outflows from an enormous number of non-direct loads of a similar sort will be included.

Harmonics in power systems can turn into the wellspring of an assortment of unwelcome impacts. For instance, harmonics can cause signal impedance, over voltages, information misfortune, and electrical switch disappointment, just as hardware warming, glitch, and harm. Any distribution circuit serving present day electronic gadgets will contain some level of symphonious frequencies. The more prominent the power drawn by nonlinear loads, cause more noteworthy the dimension of voltage bending. Potential issues (or side effects of issues) ascribed to harmonics include:

• Malfunction of delicate gear
• Random stumbling of circuit breakers
• Flickering lights
• Very high impartial currents
• Overheated stage conductors, boards, and transformers.

II. Hybrid Active Power Filters

Specialized confinements of traditional APFs can be overwhelmed with half and half APF designs. They are commonly the mix of essential APFs and uninvolved filters. Crossover APFs, acquiring the upsides of both aloof filters and APFs give improved execution and financially savvy arrangements. The thought behind this plan is to at the same time lessen the exchanging clamor and electromagnetic obstruction.

The possibility of half and half APF has been proposed by a few scientists. In this plan, a minimal effort uninvolved high-pass filter (HPF) is utilized notwithstanding the ordinary APF. The harmonics filtering task is separated between the two filters. The APF drops the lower request harmonics, while the HPF filters the higher request harmonics. The fundamental target of cross breed APF, along these lines is to improve the filtering execution of high-request harmonics while giving a practical low request harmonics alleviation.

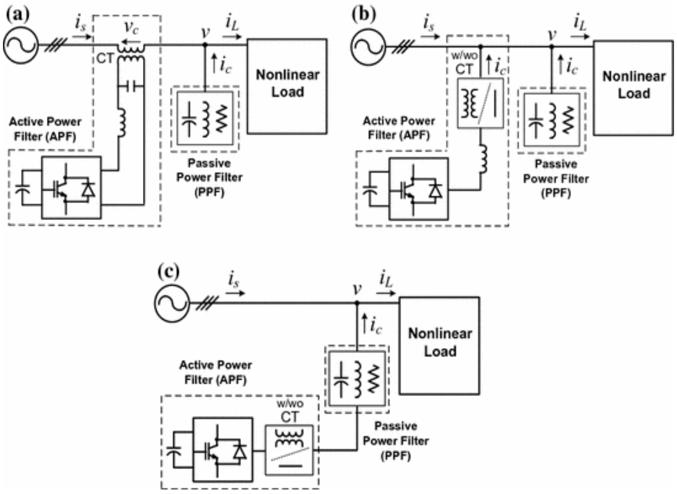

Fig.1: Hybrid Active power filter.

III. Literature Review

Z. Zeng, H. Yang, S. Tang, and R. Zhao, [1] "Multifunctional grid-tied inverters (MFGTIs) have been given much consideration to deal with the normally concerned power quality issues of the microgrids. A MFGTI cannot just interface the sustainable power source asset into the utility grid, yet additionally can remunerate the consonant and reactive current in the microgrid as an assistant help. In any case, the evident capacity of a MFGTI for power quality pay is restricted. Along these lines, how to upgrade the power nature of the microgrid by ideal use of the constrained and profitable capacity turns into a specialized test. In this paper, two ideal control goals of MFGTIs are displayed dependent on a complete power quality assessment calculation by methods for investigative chain of importance process hypothesis. One target plans to acquire the normal power quality utilizing negligible obvious capacity of the MFGTI. Another target centers around upgrading the power quality just as conceivable in the given accessible evident capacity condition. The two proposed methodologies are thought about in execution, and the paper likewise talks about how to utilize them in practice for the best execution. Test results performed on a microgrid in the research center affirm the approval and plausibility of the proposed ideal control techniques”.

A. B. Nassif, W. Xu, and W. Freitas, [2]. Passive filters have been an exceptionally successful answer for power system symphonious relief. These filters have a few topologies that give diverse recurrence reaction characteristics. The current business practice is to join filters of various topologies to achieve a specific symphonious filtering objective. Be that as it may, there is a lack of data on the most proficient method to choose diverse filter topologies. This choice depends on the experience of present filter originators. The objective of this paper is to research the filter topology choice issue. It shows our exploration results on the adequacy and expenses of different filter topologies for consonant relief. The exploration results demonstrate that the relationship of three single-tuned filters is a proper answer for most ordinary consonant issues.

M. Ali, E. Laboure, and F. Costa, [3]. This letter shows a novel coordinated structure for electromagnetic obstruction (EMI) active filter. This approach incorporates an active filter with an inactive one to shape a half breed EMI filter. The picked active filtering circuit is incorporated on the printed board circuit implanting the coordinated EMI gag. Hypothetical and acknowledgment results demonstrate the mix similarity between the active part and the inactive part. At that point, EMI estimations demonstrate that the proposed coordinated cross breed filter can incredibly lessen the commotion at high and low frequencies while decreasing the general massiveness.

F. Z. Peng, H. Akagi, and A. Nabae, [4]. An epic approach to making up for harmonics in power systems is displayed. It is a joined system of a shunt detached filter and a small appraised arrangement active filter. The pay guideline is depicted, and some filtering characteristics are talked about in detail. Amazing practicability and legitimacy to make up for harmonics in power systems are exhibited tentatively. In spite of the fact that the source symphonious voltage was just 1%, the source consonant current reached about 10% before the arrangement active filter was begun. After it was begun, no consonant current streamed into the shunt uninvolved filter. Furthermore, no symphonious voltage showed up at the terminals of the shunt inactive filter, in light of the fact that the source consonant voltage was applied to the arrangement active filter. The complete loss of the arrangement active filter was under 40 W. It is presumed that the consolidated system is far better in effectiveness than ordinary shunt active filters.

W. Tangtheerajaroonwong, T. Hatada, K. Wada, and H. Akagi, [5]. This paper tends to a transformerless shunt cross breed filter incorporated into a three-stage diode rectifier. The half breed filter comprises of a three-stage inactive filter tuned to the seventh-symphonious recurrence, and a small-appraised active filter dependent on a three-stage voltage-source pulsewidth modulation converter. The legitimacy of the system configuration is affirmed by exploratory outcomes acquired from a 400-V, 15-kW lab system. The test results demonstrate that the active filter assumes a basic job in lessening supply symphonious currents. The all out symphonious contortion of the stockpile current gets under 5%. Additionally, the half breed filter gives satisfactory transient execution because of having achieved an ideal plan of circuit and control parameters including the dc capacitor voltage and feedback increases of the active filter, alongside the cutoff recurrence of high-pass filters for symphonious extraction.

W. Guo, J. Wu, and D. Xu, [6] In this paper a novel sliding mode control approach is displayed for a medium-high voltage half breed shunt active power filter, the harmonics concealment impact of which is limited by the exchanging recurrence of power semiconductor gadgets, and EMI brought about by which is additionally related with the exchanging recurrence almost. The proposed control approach consolidates state factors tracking with PWM, in which source currents and the impartial point voltage of APF DC transport are decoupled and tracked at the same time. With comparable tracking accuracy, the exchanging recurrence can be advanced and constrained in a specific lower recurrence band through the unbiased point voltage control. A ultra-low stray inductive planar transport bar is additionally intended for APF principle circuit to limit EMI. The reenactment and trial results show that the proposed control system permits HAPF to kill symphonious currents brought about by source voltage mutilating and nonlinear loads successfully.

R. Panigrahi, B. Subudhi, and P. C. Panda, [7] "This paper proposes a straight quadratic Gaussian (LQG) servo controller for the current control of shunt-active power filter (SAPF) working under adjusted and unequal stock voltages. This LQG controller is included a LQ controller and a Kalman filter (KF) that limits the blunder between the output currents and their varieties. A feedback compensator is utilized in LQG servo controller that advantages a SAPF system by expanding tracking blunder decrease, gain soundness, diminishing sufficiency mutilation and affectability to outside unsettling influences. A KF-based new reference current age plan is created here to determine the trouble of tuning additions of a corresponding basic controller and for staying away from the utilization of voltage sensors making it financially savvy. Thus, this reference plan has self-ability of dc-connect voltage guideline by adaptively assessing the pinnacle estimation of source reference current with changing load conditions. The control calculation is implanted in SAPF utilizing a MATLAB/Simulink programming condition. The viability of the proposed LQG ServoKF calculation is assessed through correlation with a current LQRKF calculation and afterward approved with trial concentrates sought after utilizing a dSPACE1104 processing stage. From the acquired test and reenactment results, it is seen that the proposed control system displays predominant execution as far as power improvement and current harmonics moderation under consistent state and dynamic load conditions, along these lines making it progressively successful for practical applications.

S. Rahmani, K. Al-Haddad, and H. Y. Kanaan,[8]. This paper introduces a nitty gritty investigation of an arrangement half and half power filter (SHPF). The system comprises of a small-appraised arrangement active power filter and an arrangement tuned detached filter. This mix is appropriate for repaying voltage type harmonics-creating load. The half and half control approach received depends on identifying both source current and load voltage harmonics. This procedure upgrades the pay characteristics of the proposed system. A low-recurrence numerical model of the arrangement mixture filter is built up. The elaboration of the control law depends on a small-signal found the middle value of model of the converter, processed in the (d,q) synchronous casing. At that point, appropriate different circles PI controllers are planned based on the system's exchange capacities and the utilization of the straight feedback control. Reproduction results are appeared trying to confirm the scientific model of the filter and the viability of the crossover control approach for voltage harmonics remuneration.

H. De Battista and R. J. Mantz, [9]. This paper manages consonant current remuneration in power systems utilizing shunt inactive and arrangement active filters. It is demonstrated how limitations of the active filters can famously corrupt the exhibition of the repaying system. The utilization of variable structure system hypothesis is proposed for examination and plan of arrangement active filters. Sliding mode control procedures to improve symphonious dismissal are proposed, and active filters with various exchanging swell filters are considered. These control techniques give heartiness to active filter displaying mistakes and outer unsettling influences.

III. Control Strategies

3.1 INTRODUCTION

Fig. 3.1 demonstrates the schematic chart of the control and power circuit of 3-stage HSAPF. The SAPF comprises of a voltage source inverter associated with the matrix through a LC filter and a three-stage direct transformer.

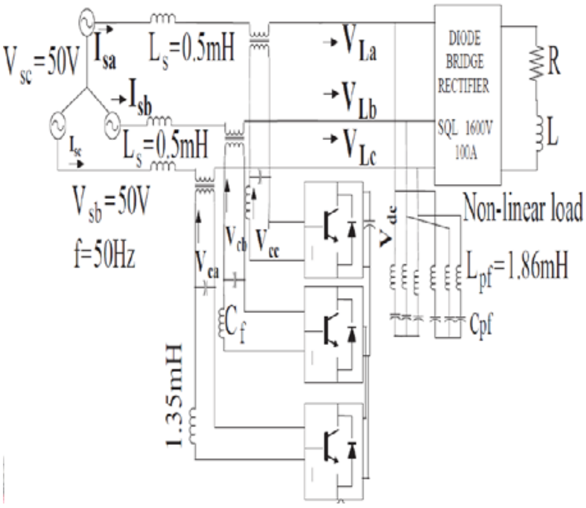

Fig. 3.1: Proposed topology.

The topology of HSAPF is made out of an arrangement associated active power filter (SAPF) and a shunt associated latent power filter (PPF). PPF associated in parallel with the load. The PPF comprises of fifth, seventh tuned LC filter of rating (L_{pf}= 1.86mH and C_{pf}= 60μF) for the pay of

consonant current on load side. The SAPF associated in arrangement with the source through a coordinating transformer of turn proportion 1:2 to guarantee galvanic seclusion. SAPF comprises of three sections, for example, three stage IGBT based SEMIKRON inverter, a DC-connect capacitor of 2200μF and a three-stage high recurrence LC filter of impedances (C_f= 60μF, L_f=

1.35mH). The high recurrence LC filter is connected to dispose of high recurrence changing swells from the remunerating voltage provided by the inverter. A non-direct load involving a three stage diode connect rectifier (ABC 100V 100A) with RL-load (i.e.resistor of 8.5A, 100 and inductor of 40mH) is considered.

IV. Sliding Mode and Dual Sliding-PI Controller Scheme

In control systems, sliding mode control (SMC) is a nonlinear control technique that modifies the elements of a nonlinear system by use of an irregular control signal (or all the more thoroughly, a set-esteemed control signal) that powers the system to "slide" along a cross-segment of the system's typical conduct. The state-input control law is definitely not a persistent capacity of time. Rather, it can change sarting with one persistent structure then onto the next dependent on the current position in the state space. Subsequently, sliding mode control is a variable structure control strategy. The various control structures are planned so directions dependably advance toward a neighboring locale with an alternate control structure, thus a definitive direction won't exist completely inside one control structure. Rather, it will slide along the limits of the control structures. The movement of the system as it slides along these limits is known as a sliding mode [1] and the geometrical locus comprising of the limits is known as the sliding (hyper)surface. With regards to current control hypothesis, any factor structure system, similar to a system under SMC, might be seen as an exceptional instance of a half breed dynamical system as the system the two moves through a consistent state space yet in addition travels through various discrete.

As of late the majority of the controlled systems are driven by electricity as it is one of the cleanest and most effortless (with smallest time consistent) to change (controllable) energy source. The change of electrical energy is illuminated by power hardware. A standout amongst the most trademark regular highlights of the power electronic gadgets is the exchanging mode. We can turn on and off the semiconductor components of the power electronic gadgets so as to diminish misfortunes supposing that the voltage or current of the exchanging component is about zero, at that point the misfortune is likewise close to zero. Along these lines, the power electronic gadgets have a place commonly with the gathering of variable structure systems (VSS). The variable structure systems make them intrigue attributes in charge hypothesis. A VSS may likewise be asymptotically steady if every one of the components of the VSS are temperamental itself. Another significant element that a VSS - with suitable controller - may get in a state where the elements of the system can be portrayed by a differential condition with lower level of opportunity than the first one. In this express the system is hypothetically totally autonomous of changing certain parameters and of the impacts of certain outside unsettling influences (for example non-direct load). This state is called sliding mode and the control dependent on this is called sliding mode control which has a significant job in the control of power electronic gadgets.

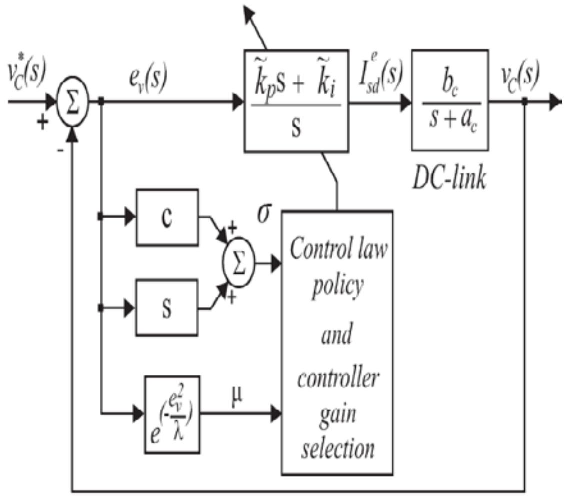

Fig. 5.1: Block diagram of the DSM − PI control scheme.

5.1 SM − PI Control Scheme: Consider the dynamic model of the dc connection of the SAPF depicted by (3) with the estimation of esr ignored. Conceding that the SM − PI controller exchange capacity can be composed as

$$C_v(s) = \frac{\tilde{k}_p s + \tilde{k}_i}{s} \quad (5.1)$$

5.2 DSM − PI CONTROL SCHEME:

The SM − PI controller has a decent exhibition amid the transient state however has an undesired symptom when the consistent state is come to. It is the prattling begun by the SMC exchanging laws utilized for figuring the controller gains. This can be relieved if the controller additions can be fixed in unfaltering state (which results in a standard PI controller). It very well may be gotten by utilizing a progress rule in the controller structure. For this, consider a Gaussian capacity defined as

$$\mu(e_v) = e^{-\frac{e_v^2}{\lambda}} \quad (5.10)$$

where μ is the choice variable to choose between the exchanging and fixed controllers, e_v is the dc-interface voltage mistake, and λ is the parameter of the Gaussian capacity. Defining a scope of qualities around the reference voltage of the dc interface, i.e., Δe_t, it is conceivable to compute the estimation of μ_t = $\mu(e_t)$, from which the controller increases of SM − PI are fixed (i.e.,$k_p = k_p^{av}$ and$k_i = k_i^{av}$), as sowed in Fig. 5.2. In this chart, the esteem μ_t speaks to the limit identified with voltage blunder e_t where the controller progress must happen.

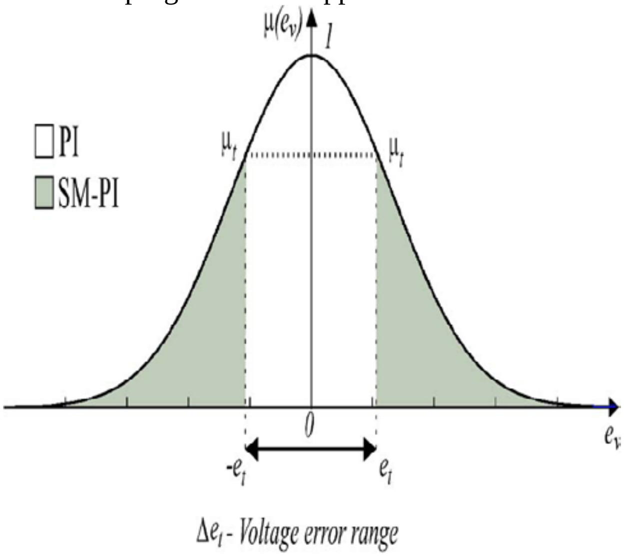

Fig. 5.2: Graph of the transition criterion μ.

Along these lines, the progress functions as pursues: By utilizing (4.10), the estimation of $\mu(e_v)$ is ceaselessly determined for every mistake voltage e_v. On the off chance that this esteem is smaller than μt, the actualized controller is the SM − PI; else, it is utilized a standard PI with antiwindup (controller SM − PI with fixed gains). To make this change smooth, it is important to sufficiently modify parameter λ. The higher λ, the less touchy is μ to the voltage blunder e_v ; generally, the smaller λ, the more delicate will be μ to the voltage mistake e_v. the square graph of the proposed DSM − PI controller, In which, the DSM − PI controller gains k_p and k_i are controlled by exchanging laws of $\widetilde{k_p}$ (5.8) and $\widetilde{k_i}$ (5.9) acquired from the sliding surface dictated by squares c and s.

V. Conclusion and Future Scope

In this paper, we have studies different types paper related to hybrid active power filter andalso studies comparative analysis between different types of controller.In this paper we have presented the three-phase hybrid active power filter for compensation of harmonic currents generated by the non-linear load. When the controller of the series active power filter is updated with DSMPI controller. Controller for faster response rate to the transients caused in the proposed system. The DSMPI controller based HPF for three-phase system is modeled and simulated in MATLAB/SIMULINK environment. This paper is also focusing on the power quality problem and their solution.

REFERENCES

[1] Z. Zeng, H. Yang, S. Tang, and R. Zhao, “Objective-oriented power quality compensation of multifunctional grid-tied inverters and its application in microgrids,” Power Electronics, IEEE Transactions on, vol. 30, no. 3, pp. 1255–1265, 2015.

[2] A. B. Nassif, W. Xu, and W. Freitas, “An investigation on the selection of filter topologies for passive filter applications,” Power Delivery, IEEE Transactions on, vol. 24, no. 3, pp. 1710–1718, 2009.

[3] M. Ali, E. Laboure, and F. Costa, “Integrated active filter for differential-mode noise suppression,” Power Electronics, IEEE Transactions on, vol. 29, no. 3, pp. 1053–1057, 2014.

[4] E. R. Ribeiro and I. Barbi, “Harmonic voltage reduction using a series active filter under different load conditions,” Power Electronics, IEEE Transactions on, vol. 21, no. 5, pp. 1394–1402, 2006.

[5] F. Z. Peng, H. Akagi, and A. Nabae, “A new approach to harmonic compensation in power systems-a combined system of shunt passive and series active filters,” Industry Applications, IEEE Transactions on, vol. 26, no. 6, pp. 983–990, 1990.

[6] S. Diptimayee Swain, P. K. Ray, and K. Mohanty, “Voltage compensation and stability analysis of hybrid series active filter for harmonic components,” in India Conference (INDICON), 2013 Annual IEEE, pp. 1–6, IEEE, 2013.

[7] W. Tangtheerajaroonwong, T. Hatada, K. Wada, and H. Akagi, “Design and performance of a transformerless shunt hybrid filter integrated into a three-phase diode rectifier,” Power Electronics, IEEE Transactions on, vol. 22, no. 5, pp. 1882–1889, 2007.

[8] high-voltage transformerless hybrid shunt active power filter,” in Industrial Electronics and Applications, 2009. ICIEA 2009. 4th IEEE Conference on, pp. 2908–2913, IEEE, 2009.

[9] B. Kedjar and K. Al-Haddad, “Dsp-based implementation of anlqr with integral action for a three-phase three-wire shunt active power filter,” Industrial Electronics, IEEE Transactions on, vol. 56, no. 8, pp. 2821–2828, 2009.

[10] R. Panigrahi, B. Subudhi, and P. C. Panda, “A robust lqg servo control strategy of shunt-active power filter for power quality enhancement,”

Power Electronics, IEEE Transactions on, vol. 31, no. 4, pp. 2860–2869, 2016.

[11] L. M. Fridman, "Singularly perturbed analysis of chattering in relay control systems," IEEE Transactions on Automatic Control, vol. 47, no. 12, pp. 2079–2084, 2002.

[12] M. A. Mulla, R. Chudamani, and A. Chowdhury, "A novel control method for series hybrid active power filter working under unbalanced supply conditions," International Journal of Electrical Power & Energy Systems, vol. 64, pp. 328–339, 2015.

[13] S. Rahmani, K. Al-Haddad, and H. Y. Kanaan, "Average modeling and hybrid control of a three-phase series hybrid power filter," in Industrial Electronics, 2006 IEEE International Symposium on, vol. 2, pp. 919–924, IEEE, 2006.

[14] S. D. Swain and P. K. Ray, "Harmonic current and voltage compensation using hsapf based on hybrid control approach for synchronous reference frame method," International Journal of Electrical Power & Energy Systems, vol. 75, pp. 83–90, 2016.

[15] H. De Battista and R. J. Mantz, "Harmonic series compensators in power systems: their control via sliding mode," Control Systems Technology, IEEE Transactions on, vol. 8, no. 6, pp. 939–947, 2000.