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Microgrid Power Quality Improvement Using Active Power Conditioner

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ABSTRACT

This paper discusses power system power quality issues and possible remedies using power electronics. Several worldwide standards This research shows how a Shunt active power filter can improve power quality in a microgrid system at the distribution level. The major goal of this study is to find an appropriate pulse generating strategy for improving the shunt active power filter's compensation capabilities. The device's compensating capability is mostly determined by the DC link capacitor voltage regulation. A fixed hysteresis current control approach has been employed in the past. An adaptive hysteresis current control technique has been developed here to improve the performance of a shunt active power filter. The suggested technique's performance has been verified in the MA TLAB/SIMULINK model platform under various operating conditions.

Keywords : Microgrid, Power quality (PQ), Shunt active power Filter, Total harmonic distortion (THD).

I. INTRODUCTION

Electrical energy is the most efficient and widely used type of energy, and modern society is strongly reliant on it. Life would be impossible to envisage without the availability of power. At the same time, the quality of the electric power delivered is critical for the proper operation of end-user equipment. 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. The voltage and frequency ranges of the power determine the quality of power given to consumers. There are many filter topologies in the literature like- active, passive and hybrid. In this project the use of hybrid power filters for the improvement of electric power quality is studied and analysed.

Increased non-linearity results in a variety of unfavourable characteristics, including low system efficiency and a low power factor. It also causes annoyance to other customers and communication network interference in the area. Over the next few years, the impact of such non-linearity could be significant. As a result, overcoming these negative characteristics is critical.

Shunt passive filters, which are made up of tuned LC filters and/or high passive filters, are traditionally used to suppress harmonics and power capacitors are used to improve power factor. However, they have fixed compensation, are huge in bulk, and can exile resonance situations. Active power filters are now seen as a viable alternative over the classical passive filters, to compensate harmonics and reactive power requirement of the non-linear loads. The objective of the active filtering is to solve these problems by combining with a much-reduced rating of the necessary passive components.

II. SHUNT ACTIVE POWER FILTER

The Figure 1 depicts a shunt active power filter diagram. At the Point of Common Coupling, a shunt active power filter is connected in parallel (PCC). PCC refers to the point where the source and load meet in the middle. In most cases, the active power filter is used.

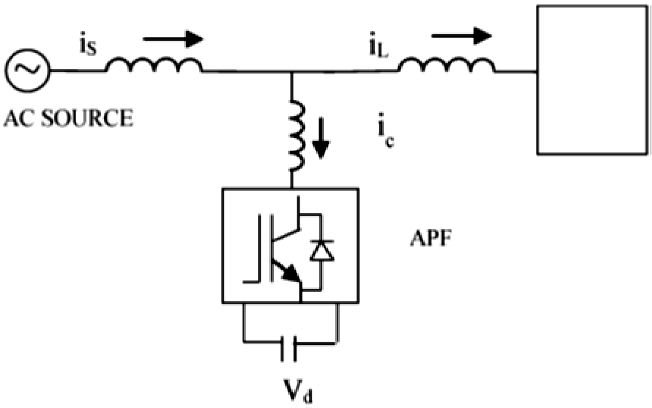

Fig 1: Shunt active power filter

The active power filter usually has an inverter structure, which can be either a voltage source inverter (VSI) or a current source inverter (CSI). Because CSI has some limitations, most of them choose VSI-based shunt active power filters. A dc link capacitor is linked to the VSI's output terminal, acting as an energy storage element and utilized to maintain a constant DC voltage with small ripple in steady state. In order to obtain better correction, the capacitor's dc link voltage must be maintained constant. This is accomplished by the use of a PI controller, which operates in a closed loop.

III. MODELLING SAPF

Figure The filter is used to reduce the harmonics and improve the power quality. The filter that is connected to the system should be controlled effectively such that its response characteristics are as desired. Among the different available filter configurations, shunt active power filter is used in this work. The control circuit of the shunt connected APF is designed such way that the voltage injected by the APF compensates the harmonics and also enhances the performance of the shunt connected passive filter. The control strategy of the shunt active power filter is explained in detail below.

The instantaneous current i_s (t) can be written as,

$$i_s(t) = i_L(t) - i_c(t) \tag{1}$$

The source voltage V_s (t) is given by,

$$V_s(t) = v_m \sin \omega t \tag{2}$$

The load current will have a fundamental and harmonic component, if a non-linear load is applied, which can be represented as,

$$i_L(t) = \sum_{i-n}^{\infty} \int sin\,(\omega t\ +\ \Phi n)$$

$$= I_1\, sin(n\omega t\ +\ \Phi 1) + \textstyle\sum_{n-2}^{\infty} \int sin\,(\omega t\ +\ \Phi n) \tag{3}$$

The instantaneous load power P_L (t) can be given as,

$$P_L(t) = V_s(t) * i_L(t) = P_f(t) + P_r(t) + P_h(t) \tag{4}$$

The fundamental real power P_f (t) drawn by the load is,

$P_f(t) = V_s(t) * i_s(t)$

$$\text{where, } i_s(t) = I_m \sin \omega t \tag{5}$$

Source current supplied by the load after compensation is,

$$i_s(t) = P_f(t) / V_s(t) = I_1 \cos\Phi_1 \sin \omega t = I_m \sin \omega t \tag{6}$$

where, $I_{sm} = I_1 \cos \Phi_1$

There are also some switching losses I_{sl} in the PWM converter and hence the utility must supply a small overhead for the capacitor leakage and converter switching losses in addition to the real power of the load. The total peak current I_{sp} supplied by the source is,

$$I_{sp} = I_{sm} + I_{sl} \tag{7}$$

If the active power filter provides the total reactive power and harmonic power, then $i_s(t)$ will be in phase with the source voltage and becomes sinusoidal. At this time the compensation current of the active power filter is,

$$i_c(t) = i_L(t) - i_s(t) \tag{8}$$

The desired source current after compensation is,

$i_{sa}^* = I_{sp} \sin \omega t$

$i_{sb}^* = I_{sp} \sin (\omega t - 120)$

$i_{sc}^* = I_{sp} \sin (\omega t + 120)$

IV. SIMULATION PARAMETER

The MATLAB simulated model is shown in fig. 2. A model is developed to simulate the PI controller-based shunt active power filter in Simulink. The complete active power filter system is composed mainly of three-phase source, a nonlinear load, a voltage source PWM converter, and a PI controller. All these components are modelled separately, integrated and then solved to simulate the system.

The parameters selected for simulation studies are given in table 1. The three phase source voltages are assumed to be balanced and sinusoidal.

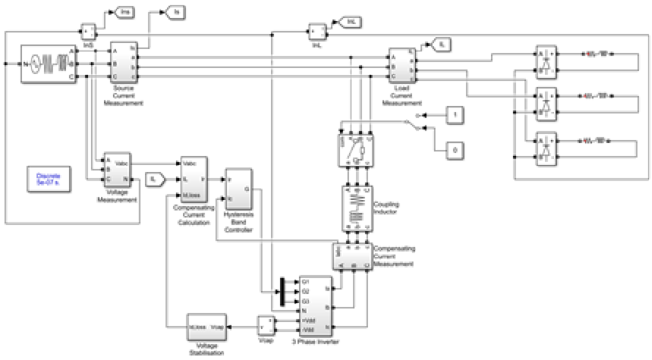

Fig. 2: MATLAB simulated model

A load with highly nonlinear characteristics is considered for the load compensation. The source current is equal to the load current when the compensator is not connected.

TABLE I

SYSTEM PARAMETERS AND THEIR VALUES.

System parameters	**Values**
Source voltage (V_s)	400V(peak)
System frequency (f)	50Hz
Source impedance (R_s, L_s)	0.1Ω;0.15mH
Filter impedance (R_c, L_c)	0.4Ω;3.35mH
Load impedance (R_l, L_l)	6.7Ω;20mH
DC link capacitance	2000μF
Reference DC link voltage (V_{dcref})	220V

From the fig 3, It is clear that, the source current and source voltage are not in phase with each other. Due to this, the power factor of the system is reduced and system becomes unstable. The change in system parameters such as voltage, current, and frequency caused by these complicated loads is referred to as "power quality concerns."

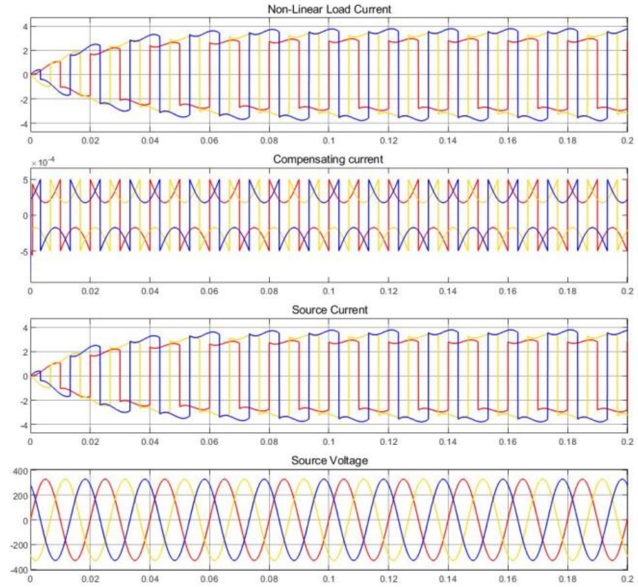

Fig 3: show the result of simulation of model before applying power filter to the system of non-linear load current, compensating current, source current and source voltage of phase R, Y and B respectively.

Poor power quality causes device and equipment failure, harmonics and unbalances in voltage and current, low power factor, and reactive power consumption. The major index for poor power quality is among these harmonics. As a result, it is vital to address these power quality issues and keep the % THD below specified limits, as dictated by IEEE standards.

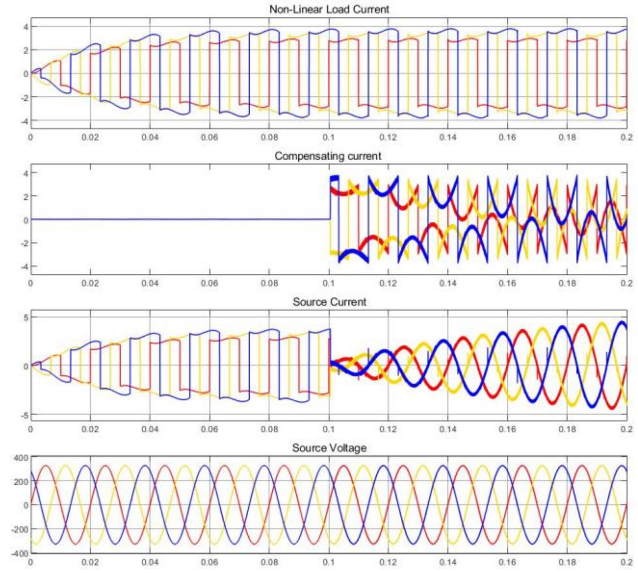

Fig 4: switching compensating current at t=0.1sec.

The compensator is switched ON at t=0.1s and the integral time square error (ITSE) performance index is used for optimizing the and coefficients of the PI controller. The optimum values are found to be 0.2 and 9.32, respectively, which corresponds to the minimum value of ITSE. The source currents as well as compensating currents for PI controllers are shown in fig 4.

From the wave forms it is clear that harmonic distortion is reduced after connecting compensator. The PI controller gives better harmonic compensation. From the responses it is depicted that the settling time required by the PI controller is approximately 10 cycles. In Fig 5 The THD of source current before switching Active Power Filter is shown. The number of cycles for calculating the percentage of THD of source current is 8 cycles selected from 0.2 sec. The THD of source current before applying Active power filter is 47.80%. The source voltage and source current are not in phase with each other. Due to this, the power factor is affected and the system is not stable.

The fig. 6 shows THD after applying the current compensation to the system. The settling time required for PI controller is approximately 10 cycles. The number of cycles for calculating the percentage of THD of source current is 8 cycles selected from 0.2 sec. The THD of source current after applying Active power filter is 3.18%. The source current becomes harmonic free after applying current compensation.

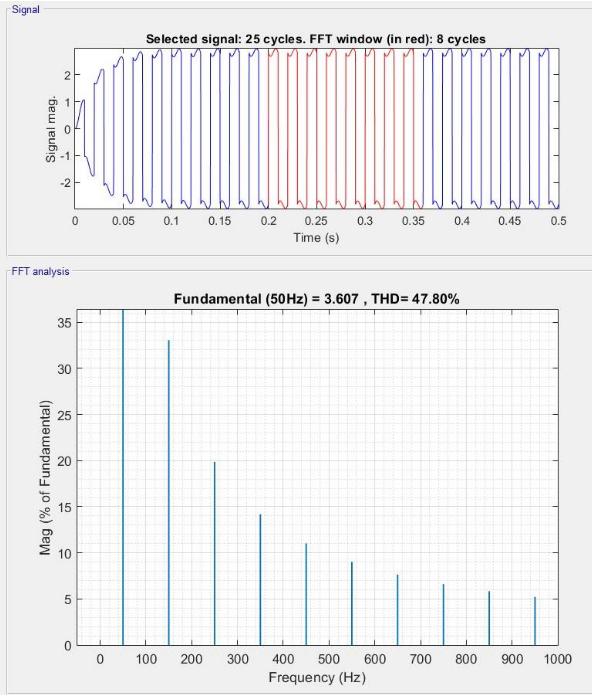

Fig 5: Total Harmonic Distortion (THD) before current compensation

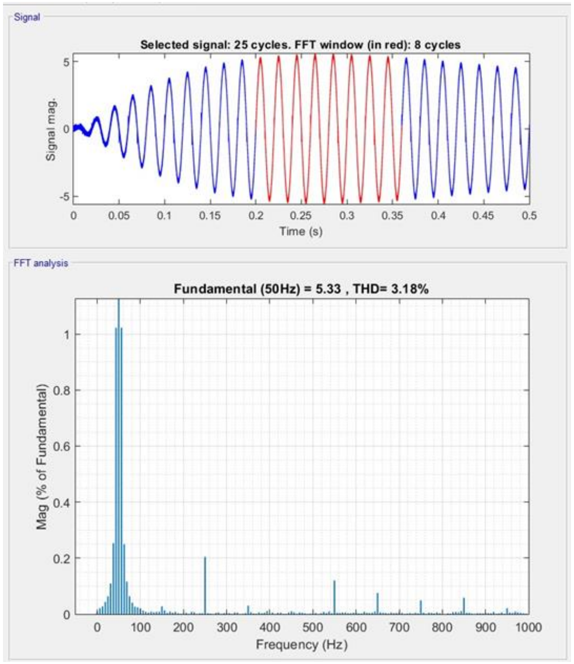

Fig 6: Total Harmonic Distortion (THD) after current compensation

The source current THD is reduced from 47.80% to 3.18% as shown in fig 5 and 6, the THD is reduced by 44.62%. After compensation both source voltage and current are in phase with each other means that the harmonics are eliminated and reactive power is compensated to make power factor close to unity. As the source current is becoming sinusoidal after compensation power quality is improved.

V. CONCLUSION

A shunt active power filter has been investigated for power quality improvement. Various simulations are carried out to analyse the performance of the system. The PI controller-based Shunt active power filter is implemented for harmonic and reactive power compensation of the non-linear load. A program has been developed to simulate the PI controller-based shunt active power filter in MATLAB. It is found from simulation results that shunt active power filter improves power quality of the power system by eliminating harmonics and reactive current of the load current, which makes the load current sinusoidal and in phase with the source voltage. According to IEEE 519 standard, the maximum permissible THD for low voltage application is 5% and maximum permissible for individual voltage harmonics is 3%. The performance of the controllers has satisfied the IEEE standards as the resulted THD of source current after applying compensation is below permissible limit. A model has been developed in MATLAB SIMULINK and simulated to verify the results.

VI. REFERENCES

[1] H. Awad and M. H. J. Bollen, "Power electronics for power quality improvements," 2003 IEEE International Symposium on Industrial Electronics (Cat. No.03TH8692), 2003, pp. 1129-1136 vol. 2, doi: 10.1109/ISIE.2003.1267983.

[2] B. Singh, K. Al-Haddad and A. Chandra, "A review of active filters for power quality improvement," in IEEE Transactions on Industrial Electronics, vol. 46, no. 5, pp. 960-971, Oct. 1999, doi: 10.1109/41.793345.

[3] D. Rivas, L. Moran, J. Dixon and J. Espinoza, "Improving passive filter compensation performance with active techniques," Ninth International Conference on Harmonics and

Quality of Power. Proceedings (Cat. No.00EX441), 2000, pp. 232-238 vol.1, doi: 10.1109/ICHQP.2000.897030.

[4] R. S. Herrera and P. Salmeron, "Instantaneous Reactive Power Theory: A Comparative Evaluation of Different Formulations," in IEEE Transactions on Power Delivery, vol. 22, no. 1, pp. 595-604, Jan. 2007, doi: 10.1109/TPWRD.2006.881468.

[5] P. Salmeron and S. P. Litran, "Improvement of the Electric Power Quality Using Series Active and Shunt Passive Filters," in IEEE Transactions on Power Delivery, vol. 25, no. 2, pp. 1058-1067, April 2010, doi: 10.1109/TPWRD.2009.2034902.

[6] S. Rahmani, A. Hamadi, N. Mendalek and K. Al-Haddad, "A New Control Technique for Three-Phase Shunt Hybrid Power Filter," in IEEE Transactions on Industrial Electronics, vol. 56, no. 8, pp. 2904-2915, Aug. 2009, doi: 10.1109/TIE.2008.2010829.

[7] R V D Rama Rao & Subhransu S. Dash, "Enhancement of Power Quality by using Unified Power Quality Conditioner with PID and Fuzzy Logic Controller", International Journal of Computer Applications, vol. 5, no. 2, pp. 21-27, Aug 2010, doi: 10.5120/925-1303.

[8] P. Karuppanan and K. Mahapatra, "PLL with PI, PID and Fuzzy Logic Controllers based shunt Active Power Line Conditioners," Joint International Conference on Power Electronics, Drives and Energy Systems & 2010 Power India, 2010, pp. 1-6, doi: 10.1109/PEDES.2010.5712506.

[9] T. Mahalekshmi, "Current harmonic compensation and power factor improvement by hybrid shunt active power filter," International Journal of Computer Applications (0975 – 8887), vol. 4, no. 3, pp. 9-13, Jul. 2010.

[10] P. Salmeron and S. P. Litran, "Improvement of the Electric Power Quality Using Series Active and Shunt Passive Filters," in IEEE Transactions on Power Delivery, vol. 25, no. 2, pp. 1058-1067, April 2010, doi: 10.1109/TPWRD.2009.2034902.

[11] H. Sasaki and T. Machida, "A New Method to Eliminate AC Harmonic Currents by Magnetic Flux Compensation-Considerations on Basic Design," in IEEE Transactions on Power Apparatus and Systems, vol. PAS-90, no. 5, pp. 2009-2019, Sept. 1971, doi: 10.1109/TPAS.1971.292996.

[12] A. Cavallini and G. C. Montanari, "Compensation strategies for shunt active-filter control," in IEEE Transactions on Power Electronics, vol. 9, no. 6, pp. 587-593, Nov. 1994, doi: 10.1109/63.334773.

[13] K. V. Kumar, G. Surendar, M. P. Selvan, "Performance comparison of shunt active filter and hybrid active filter," National Science Conference, pp. 71-76, Dec. 2008.

[14] M. Peterson, B. N. Singh and P. Rastgoufard, "Active and Passive Filtering for Harmonic Compensation," 40th Southeastern Symposium on System Theory (SSST), 2008, pp. 188-192, doi: 10.1109/SSST.2008.4480217.

[15] F. Rong, J. Yu and A. Luo, "Reference Current Computation Method Based on Adaptive Low-Pass Filter for Active Power Filter," International Conference on Measuring Technology and Mechatronics Automation, 2010, pp. 996-999, doi: 10.1109/ICMTMA.2010.26.

[16] W. Li-ping, S. Zhen-yin and Y. De-zhou, "A three-phase active power filter based on the space vector theory," 5th International Conference on Computer Science & Education, 2010, pp. 1279-1282, doi: 10.1109/ICCSE.2010.5593725.

[17] Z. Xi, Z. Xin, S. Zhou, W. Huang and L. Qi, "A Novel Shunt Active Power Filter Under Condition of Unbalanced Voltage," Asia-Pacific Power and Energy Engineering Conference, 2010, pp. 1-4, doi: 10.1109/APPEEC.2010.5449115.

[18] Mohamed El-Habrouk, "A new Configuration for Shunt Active Power Filters", PhD Thesis, Brunel University, 1998.

[19] Singh, B.; Al-Haddad, K.; Chandra, A.: 'Active power filter with sliding mode control', IEEE Proceedings - Generation, Transmission and Distribution, 1997, vol. 144, issue 6, pp. 564-568, doi: 10.1049/ip-gtd:19971431

[20] A. Luo, Z. Shuai, W. Zhu and Z. J. Shen, "Combined System for Harmonic Suppression and Reactive Power Compensation," in IEEE Transactions on Industrial Electronics, vol. 56, no. 2, pp. 418-428, Feb. 2009, doi: 10.1109/TIE.2008.2008357.

[21] R. S. Herrera, P. SalmerÓn and H. Kim, "Instantaneous Reactive Power Theory Applied to Active Power Filter Compensation: Different Approaches, Assessment, and Experimental Results," in IEEE Transactions on Industrial Electronics, vol. 55, no. 1, pp. 184-196, Jan. 2008, doi: 10.1109/TIE.2007.905959.

[22] M. Abdusalam, P. Poure and S. Saadate, "A New Control Scheme of Hybrid Active Filter Using Self-Tuning-Filter," International Conference on Power Engineering, Energy and Electrical Drives, 2007, pp. 35-40, doi: 10.1109/POWERENG.2007.4380095.

[23] M. T. Haque, "A control strategy based on extended p-q theory usable in parallel active filters," IEEE International Symposium on Industrial Electronics, 2004, pp. 791-796 vol. 2, doi: 10.1109/ISIE.2004.1571914.

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