ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Website: www.ijareeie.com

Vol. 7, Issue 11, November 2018

A Comprehensive Review of Shunt Active Power Filter

Adnan Khan[1], S.M Shembekar[2]

PG Student [EPS], Dept. of Electrical, SSBT's COET, Bambhori, Jalgaon, Maharashtra, India[1]

Assistant Professor, Dept. of Electrical, SSBT's COET, Bambhori, Jalgaon, Maharashtra, India[2]

ABSTRACT: Power quality is a big concern nowadays.It become important, especially with the introduction of advanced power electronics devices and expanded network. Power quality problem is the issue that takes place before a non-standard voltage, current, or frequency, leading to end-use hardware failure. One of the main issues addressed here is voltage sag. To resolve this issue, one must use custom and advaned power devices. One of these devices is the Shunt Active Power Filter (SAPF), a modern power device used in the most efficient power distribution networks. To deal with such power quality problems at transmission and distribution level , devices like SAPF plays important role.
.

KEYWORDS:SAPF, VSC, Voltage dips, PCC, Power Quality, UPS

I.INTRODUCTION

Power quality is becoming an increasingly important topic in the performance of many industrial applications such as information technology, significant influence on high technology devices related to communication, advanced control, PLC SCADA, precise manufacturing technique and on-line service, power hubs etc. Utility companies need constant sine wave shape, constant frequency and stable voltage with a constant root mean square (rms) value to continue the production. To satisfy these demands, the disturbances must be eliminated from the system. The typical power quality disturbances are voltage sags, voltage swells, interruptions, phase shifts, harmonics and transients [1]. Among the disturbances voltage sag is considered the most severe since the sensitive loads are very vulnerable to temporary changes in the voltage. Voltage sag is a temporary reduction in voltage magnitude. The voltage temporarily drops to a lower value and regain after approximately 150ms. Despite their short duration, such events can cause serious problems for a wide range of equipment [2]. The characterization of voltage sags is related with:
1. The magnitude of remaining voltage during sag
2. Duration of sag

In practice the magnitude of the remaining voltage has more impact than the duration of sags on the system. Voltage sags are generally within 40% of the nominal voltage in industries. Voltage sags can cost millions of dollars in damaged equipments, lost production, restarting expenses and risk of breakdown [3][4].

Short circuit faults, motor starting and transformer energizing will cause short duration increase in current and this will cause voltage sags on the line. For certain end users of sensitive equipment the voltage correction device may be the only cost-effective option available.

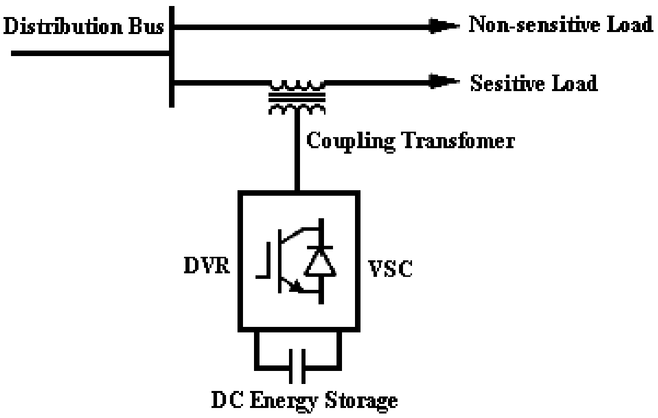
ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Website: www.ijareeie.com

Vol. 7, Issue 11, November 2018



Basic Configuration of SAPF

There are different approaches to counter and limit the costs caused by voltage sags and one interesting approach considered here is to use voltage source converters connected in series between the supply system and the sensitive loads, this type of devices are often termed a Shunt Active Power Filter (SAPF).

Unlike uninterruptible power supply (UPS), the SAPF is specifically designed for large loads ranging from a few MVA up to 50 MVA or higher [10]. The SAPF is fast, flexible and efficient solution to voltage sag problems. It can regain the load voltage within a few milliseconds and hence avoiding any power disruption to that load. The main idea of the SAPF is detecting the voltage sag and injecting the missing voltage in series to the bus by using an injection transformer as shown in Figure 2.

The SAPF can be divided into four component blocks, namely:

1.Voltage source PWM inverter
2. Injection/coupling transformer
3. Energy storage device

II. PROPERTIOUS CHOICE OF SAPF

There are numerous reasons why SAPF is preferred over other devices:

1. Although, SVC predominates the SAPF but the latter is still preferred because the SVC has no ability to control active power flow.
2. SAPF is less expensive compared to the UPS.
3. UPS too needs high degree of maintenance because it has problems of battery leak and have to be replaced as often as 5 years.
4. SAPF has a relatively higher energy capacity and costs less compared to SMES device.
5. SAPF is smaller in size and costs less compared to DSTATCOM
6. SAPF is power efficient device compared to the UPS.

III. CONVENTIONAL CONTROL STRATEGIES

Several control techniques have been proposed for voltage sag compensation such as pre-sag method, in-phase method and minimal energy control [5] [6].

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Website: www.ijareeie.com

Vol. 7, Issue 11, November 2018

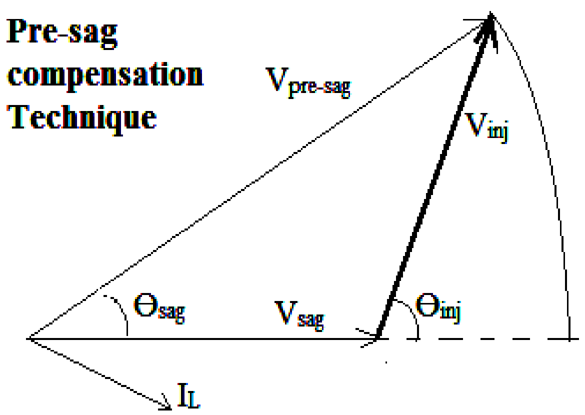
1. General Compensation Technique

The phasors of load voltages as well as load currents, will rotate with respect to the pre-sag voltages while the phasors of the supply sag voltages will not change. During the normal operation as there is no sag, SAPF will not supply any voltage to the load. It will go into a standby mode or it operates in the self-charging mode if the energy storage device is fully charged. The energy storage device can be charged either from the power supply itself or from a different source

2. Pre-Sag Compensation Technique

The main defect of this technique is it requires a higher capacity energy storage device. Fig.2 shows the phasor diagram for the pre-sag control strategy in this diagram; Vpre-sag and Vsag are voltage at the point of common coupling (PCC), respectively before and during the sag. In this case VSAPF is the voltage injected by the SAPF, which can be obtained as [9]:
Vpre-sag=VL, Vsag=Vs VSAPF=Vinj
| Vinj | = | Vpre-sag | – | Vsag | .... (1)

$$\theta inj=\tan^{-1}\{\frac{Vpre-sag\ \sin(\theta pre-sag)}{Vpre-sag\ \cos(\theta pre-sag)-Vsag\ \cos(\theta sag)}\}$$



2.In-Phase Compensation Technique

In this technique, only the voltage magnitude is compensated. VSAPF is in-phase with the left hand side voltage of SAPF. This method minimizes the voltage injected by the SAPF, unlike in the pre-sag compensation. Fig.2 shows phase diagram for the in-phase compensation method [9].
VSAPF=Vinj
| Vinj | = | Vpre-sag |–| Vsag |

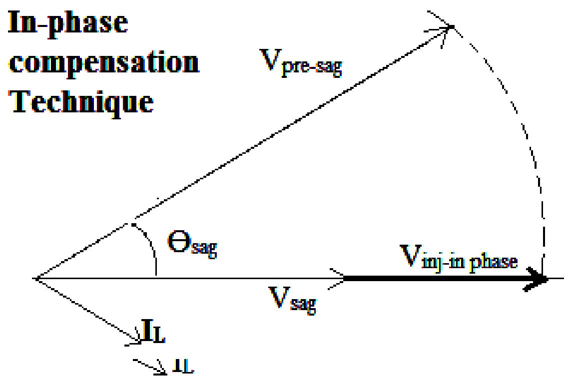
ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Website: www.ijareeie.com

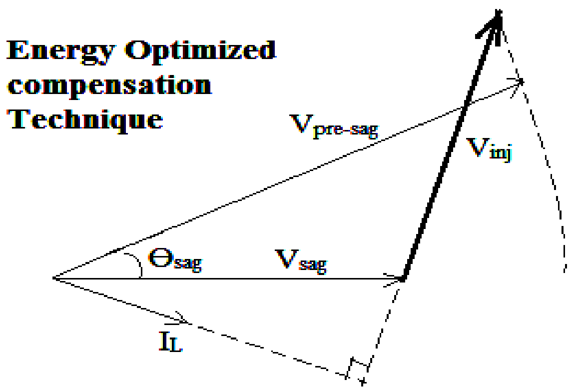
Vol. 7, Issue 11, November 2018



3.Energy Optimized compensation Technique

Pre-sag compensation and in-phase compensation together should inject active power to loads almost all the time. Due to the limit of energy storage capacity of DC link, the SAPF restoration time and performance are confined in these methods. The basic idea of energy optimization method is to bring the injection of active power to zero. For the purpose to minimize the use of real power, the voltages are injected at 90° phase angle to the supply current. Fig.2 shows us a phasor diagram which describe the Energy optimization Control method.

The selection of one of these strategies influences the design of the parameters of SAPF. In this paper, the control strategy adopted is Pre-sag compensation to maintain load voltage to pre fault value [12].



VI.CONCLUSION

This paper aims at summarizing the SAPF technology and also discusses about the various ins and outs of the implementation procedures for SAPF . In section 1 the basic review of the SAPF technology was presented , in section 2 the advantage of SAPF over other technologies was discussed , in section three various implementation schemes for SAPF were discussed and finally in section 3 a mathematical model for future implementation has been covered [14] . It has been shown that there are sevral ways in which the SAPF can be implemented to reduce harmonics in a complex power system.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Website: www.ijareeie.com

Vol. 7, Issue 11, November 2018

REFERENCES

[1] Neha Kaushik, "Power Quality, Its Problem and Pwer Quality monitoring", International journal of electrical engineering and Technology Volume 4, Issue 1,January February (2013),pp.46-57

[2] Subhamita Roy, and SudiptaNath, "Classification of power quality disturbances using featuresof signals," International Journal of Scientific Publications, Vol. 2, Issue 11, November 2012,pp.01-09.

[3] N. Kandil, V.K.Sood, K.Khorasani, and R.V. Patel, "Fault identification in an AC-DCtransmission system using neural networks," IEEE transactions on Power System, Vol. 7, No. 2,May 1992, pp. 812-819.

[4] C. Zhan,A. Arulampalam, and N.Jenkins, "Four-wire shunt active power filter on a three-dimensional voltage space vector PWM algorithm," *IEEE Trans. Power Electron.*, vol. 18, no. 4, pp. 1093–1102, Jul. 2008.

[5] B. Wang, G. Venkataramanan, and M. Illindala, "Operation and control of a dynamic voltage restorer using transformer coupled H-bridge converters," *IEEE Trans. Power Electron.*, vol. 21, no. 4, pp. 1053–1061 , Jul. 2006.

[6] P. R. Sánchez, E. Acha, J. E. O. Calderon, V. Feliu, and A. G. Cerrada, "A versatile control scheme for a shunt active power filter for power-quality improvement," *IEEE Trans. Power Del.*, vol. 24, no. 1, pp. 277–284, Jan. 2009.

[7] P. Boonchiam and N. Mithulananthan, "Dynamic control strategy in medium voltageDVRformitigatingvoltagesags/swells,"in*Proc. PST*, 2006, pp. 1–5.

[8] S. Sasitharan and M. K. Mishra, "Design of passive filter components for switching band controlled DVR," in *Proc. TENCON*, 2006, pp. 1–6.

[9] H. K. Al-Hadidi, A. M. Gole, and D. A. Jacobson, "A novel configuration for a cascade inverter-based shunt active power filter with reduced energy storage requirements," *IEEE Trans. Power Del.*, vol. 23, no. 2 , pp. 881–888, Apr. 2010.

[10] Y. W. Li, D. M. Vilathgamuwa, F. Blaabjerg, and P. C. Loh, "Investigation and improvement of transient response of SAPF at medium voltage level," *IEEE Trans. Ind. App.*, vol. 43, no. 5, pp. 1309–1319, Sep./Oct. 2007.

[11] J. G. Nielsen and F. Blaabjerg, "A detailed comparison of system topologies for shunt active power filter," *IEEE Trans. Ind. Appl.*, vol. 41, no. 5, pp. 1272–1280, Sep./Oct. 2005.

[12] C. Meyer, R. W. De Doncker, Y. W. Li, and F. Blaabjerg, "Optimized control strategy for a medium-voltage DVR—Theoretical investigations and experimental results," *IEEE Trans. Power Electron.*, vol. 23, no. 6, pp. 2746–2754, Nov. 2010.

[13] D. M. Vilathgamuwa, A. A. D. R. Perera, and S. S. Choi, "Voltage sag compensation with energy optimized shunt active power filter," *IEEE Trans. Power Del.*, vol. 18, no. 3, pp. 928–936, Jul. 2003.

[14] P. Roncero-Sanchez and E. Acha, " Active power filter based on flying capacitor multilevel converters operated by repetitive control," *IEEE Tran. Power Del.*, vol. 24, no. 2, pp. 951–960, Apr. 2009.

[15] E. Babaei, S. H. Hosseini, G. B. Gharehpetian, M. T. Haque, and M. Sabahi, "Reduction of dc voltage sources and switches in asymmetrical multilevel converters using a novel topology," *Elsevier J. Elect. Power Syst. Res.*, vol. 77, no. 8, pp. 1073–1085, Jun. 2007.