A Review on Control of Shunt Active Power Filter Using Instantaneous Symmetrical Component Technique

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Abstract:

This paper presents the review on the power quality enhancement using shunt active power filters (SAPF) for a threephase supply system feeding three-phase balanced non-Linear Load. Improving power quality has been the major research topic in last few decades due toflooding of semiconductor and other non-linear devices. The power quality of any sourceis judged by the some indexes defined by international bodies such harmonics factor, telephonic interference level (TIF) etc. Using the different harmonic compensationschemes we must be able to meet those index limits. This is very important in referenceto performance and economy of operation. Power filters are widely used in modern electrical distribution system to eliminate the harmonics associated with it.

Keywords: Artificial Neural Network (ANN), Active Power Filter (APF), Distribution Static Synchronous Compensator (DSTATCOM), Phase Angle Control (PAC)

1. INTRODUCTION

Electrical energy generation from the renewable energy resources are the growinginterest in electrical energy distribution networks which creates more power qualityproblems. In such situations Electricity supplier and the electricity consumers areconcerned about power quality of the electric supply. To fulfil the consumer requirementelectricity supplier makes several efforts. Some consumers in the modern power networkdemands higher level than the level of power quality supplied by the utilities. Thisimplies that some measures should be taken so that the power quality of the high-level isobtained.

Electricity has been and will always be an important part of our lives. As a consumer, wehave to ensure that electricity is efficiently distributed, controlled and used. On one hand,it is the duty of utilities to ensure reliable supply of electricity to consumers. On the otherhand, large loads customers (factories, large stores and etc.), have to ensure that they bindto electricity standards. So that their loads will neither affect utility equipment nor disruptthe flow of electricity to adjacent customers. Improving power quality has been the majorresearch topic in last few decades due to flooding of semiconductor and other non-lineardevices. The term Power Quality encompasses all aspects pertaining to the quality of theelectrical supply in terms of the magnitude and frequency of the voltage and currentwaveforms [1]. Numerous phenomena like harmonics, voltage sag/swell, flickers, notching, resonance, unbalanced three phase systems, grounding etc. influence electricalsystem power quality. The power quality of any source is judged by the indexes namedabove defined by international bodies.

2. EFFECTS OF POOR QUALITY

The effects of poor power quality are vast and versatile. Among many, it reduces the life expectancy of electrical components [2] and disturbs the operation of protection devices [3] [4] [5]. For example, in India, the core of any distribution transformer is designed for optimaloperation at 50Hz. Distorted currents drawn by large non-linear loads impose higherfrequencies on top of the fundamental frequency component of the current waveform.

Since transformer iron core eddy current loss is related to the square of supply frequency,hysteresis loss is proportional to frequency to the power of α (where α is the the range of1.5-2) and excess loss which is proportional to frequency to the power 3/2 [6]. Continuous distorted load currents increase transformer losses and hence contribute togeneral temperature rise and potential local hotspots. Further, current harmonics causeadditional copper losses in all equipment. These additional losses raise the transformer (and other equipment) temperatures above nominal design levels, a feature that couldaccelerate the aging of distribution transformers through thermal stress and potentiallycause premature component failure [1][2]. Keeping that in mind, transformers and otherequipment would then require more frequent maintenance which will increase the totaloperating cost of the electrical system.

Research has shown that high harmonic content can have further negative impacts onpower system performance, as protection relays are built to operate at a nominalfrequency (50/60 Hz) [3]. Previous research indicated that some relays may mis-operateand trip under what are considered ‘normal’ operating conditions, or conversely, fail totrip entirely in the presence of harmonics [3-8]. False or missed relay tripping may resultin system failure, service discontinuity or other economic losses.

Major Sources of harmonics are:

- Non-Linear Power electronic Devices
- Saturated Core Transformer
- Uninterrupted Power Supply(UPS)
- Adjustable Speed Drives etc.

Adverse Effects of harmonics:

1. Overheating of transformer
2. Excessive neutral Current
3. Low power factor and excessive copper and core losses
4. Damage to Power drives
5. Malfunction of sensitive Equipment
6. Capacitor Blowing

3. POWER QUALITY PHENOMENA

Power quality is a range of phenomena related to deterioration of current and voltagewaveforms from ideal shape. Many definitions of power quality have been proposed, butvariety of related phenomena is too wide to cover. In this thesis the term power quality isused with reference to parameters of voltage delivered to the load. The following sectionswill describe fundamental definitions related to supply voltage quality.

An overview of power quality phenomena is presented in Fig. 1.1. First group includeslong-term variations of current or/and voltage waveforms. Voltage and current are heretreated separately, although both are related to each other. In the most cases origin ofvoltage variations is non-ideal load current. To understand the problem, some aspects ofdistribution network operation are discussed in Section 3.2. The second group includesevents, which are single incidents that influence voltage in the network. These are usuallycaused by network events, such as short-circuit or switching.

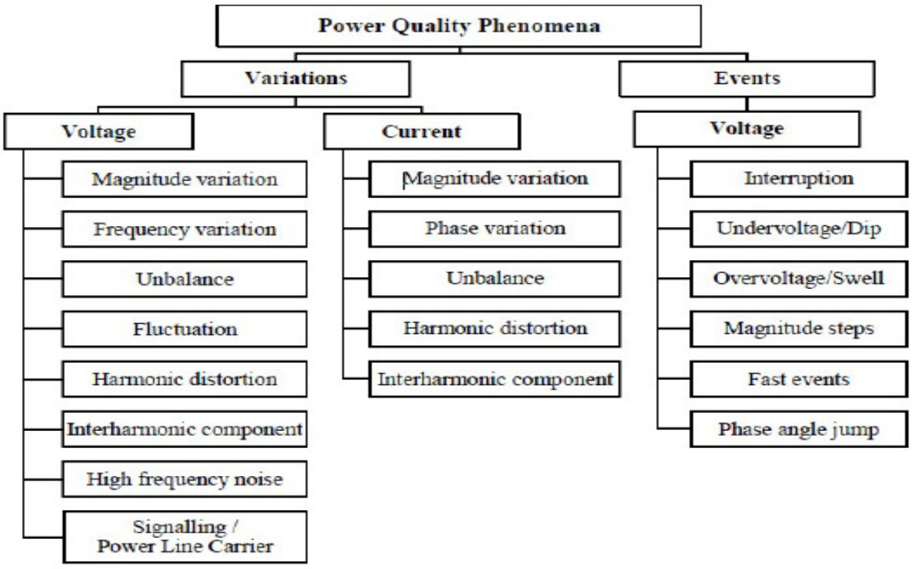

Fig. 1: Classification of power quality phenomena

4. LITERATURE SURVEY

In the present scenario, power quality has become one of the major factors both forelectric suppliers and consumers. Deterioration of power quality results in heavy lossin power distribution system and also leads to the failure of electrical systems.

Therefore to mitigate power quality problems power quality conditioners came into picture.

N.G. Hingorani [2] explains the concept of custom power device and power qualitydue to advancement of power electronics application in the industry.A.Ghosh and G. Ledwich [4] explains the enhancement of power quality usingcustom power devices. These devices considers the structure, control and performanceof series compensating DVR, the shunt SAPF and the shunt with series UPQC forpower quality improvement in electricity distribution system.

A. Moreno-Munoz [3] writes a book about the improvement in power quality by themitigation technologies in the distributed environment.

The reliability of the system is highly affected by the quality of power discussed byDuganet al. [4] and Schlabbachet al. [5]. Below diagram shows different powerquality problems.

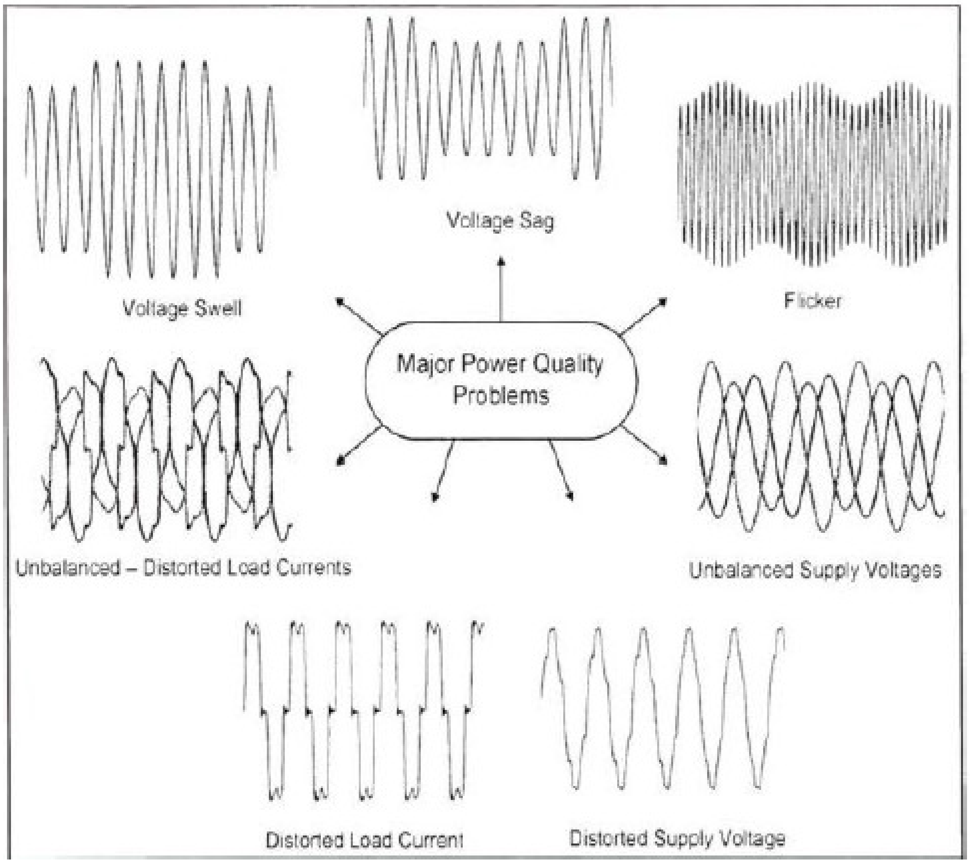

Fig. 2: Pictorial View of Major Power Quality Problems

S. Khalid et al. [6] presented the harmonic distortion and low power factor usingDistribution Static Compensator (SAPF). The model is based on the Voltage SourceConverter (VSC) principle. The SAPF injects a current into the system to mitigate theharmonic distortion and improve power factor.

G. Arindhum et al. [7] explains about the operating principles of a distribution staticcompensator (SAPF) which is used to maintain constant voltage in the distributionsystem. A three-phase voltage source converter supplied by DC storage capacitorsrealizes the SAPF.

B.S. Chen et al. [8] gives a novel controller with fixed modulation index (MI) andvariable dc capacitor voltage reference to minimize voltage and current harmonics ispresented for a distribution static synchronous compensator (SAPF).

Zaveri T. et al. [9]presents a novel approach based on an improved instantaneousactive and reactive current component theory for generating reference currents fordistribution static compensator (SAPF). The performance of the SAPF using theproposed control strategy has been evaluated under various source and loadconditions. The performance of the proposed control strategy has been evaluated interms of load balancing, reactive power compensation and harmonic mitigation.

F. Z. Penget al. [10] theory gives a generalized definition of instantaneous reactivepower, which is valid for sinusoidal or non-sinusoidal, balanced or unbalanced, threephasepower systems with or without zero-sequence currents and/or voltages. A threephaseharmonic distorted power system with zero-sequence components is then usedas an example to show reactive power measurement and compensation.

E. D. Watanabe et al. [11] uses the concepts of symmetrical components togetherwith the new theory for the analysis of the powers in an unbalanced system includingthe zero-sequence instantaneous power.

B.Singh et al. [12] explains the three-phase compensator for load balancing andreactive power compensation in three-phase four-wire Electrical power distributionsystems.

H. Akagi et al. [13] gives the generalised theory of instantaneous reactive power alsocalled as p-q theory.

B. Singh et al. [14] compares the different control algorithms used for SAPF andresults are compared on the basis of total harmonic distortion, load balancing andreactive power compensation. The compared theories are instantaneous reactive powertheory, SRF theory.

M.K. Mishra et al. [15] consider two kinds of compensation methods. In the firstcategory, synchronous detection and modified equal current strategies are used underthe unbalanced but sinusoidal source voltages. In the second method, loadcompensation based on instantaneous symmetrical component theory with positivesequence extraction is proposed and is shown to work under unbalanced and the non-sinusoidalsource voltages. These both the methods are analysed under linear and nonlinearloading conditions.

5. CONCLUSION

In this paper different types of power quality problems arises in the system, theircause and effects are discussed. Limitations of passive filters and advantages of activefilter over passive are also discussed. To mitigate these problems SAPF with differentcontrol algorithms used in different paper are also analysed. After analysing differentcontrol techniques the following research areas are identify for further study as thebest suitable control strategy to control SAPF is Instantaneous SymmetricalComponent Theory.

REFERENCES

[1] IEEE Recommended Practices and Requirements for Harmonics Control inElectric Power Systems, IEEE Std.519, 1992.

[2] V. Khadkikar, A. Chandra, "A novel structure for three-phase four-wiredistribution system utilizing unified power quality conditioner(UPQC),"IEEE Trans. on Ind. Appl. ,vol. 45, no. 5, pp. 1897-1902, Oct. 2009.

[3] N. Hingorani, "Introducing Custom Power," IEEE Spectrum, Vol.32, Issue:6, June 1995.

[4] R. C. Dugan, Mark F. McGranghan, Surya Santoso, H. Wayne Beaty,"Electrical Power System Quality", 3rd Edition, McGraw Hill Publication.

[5] A.Ghosh and G. Ledwich, Power Quality Enhancement using CustomPower devices, Kluwer Academic Publishers, London, 2002.

[6] Moreno-Munoz, Power Quality: Mitigation Technologies in aDistributed Environment. London, U.K.: Springer-Verlag, 2007.

[7] Dugan C. R., M. F. McGranaghan and H. W. Beaty. 1996. ElectricalPowerSystems Quality, New York, N. Y.: McGraw-Hill, pp. 265-271.

[8] Schlabbach J., D. Blume and T. Stephanblome. 2001. Voltage Quality inElectrical Power Systems, London, Angleterre: Institution of ElectricalEngineer, pp. 241-246.

[9] S. Khalid, Y. Naveen Kumar and D.Archana, "Power Quality Improvementin Distribution System Using D-STATCOM In Transmission Lines",IJERA, ISSN: 2248-9622, Vol. 1, Issue 3, pp.748-752, 2011.

[10] G. Arindhum, M. K. Mishra, "Operation of a DSTATCOM in voltagecontrol mode," IEEE Trans. on Power Del., vol. 18, no. 1, pp. 258–264,Jan.2003.

[11] B.-S. Chen and Y.-Y. Hsu, "A minimal harmonic controller for aSTATCOM," IEEE Trans. Ind. Electron., vol. 55, no. 2, pp. 655–664, Feb.2008.

[12] Zaveri T., Bhalja B. R Zaveri N.: 'A novel approach of reference currentgeneration for power quality improvement in three-phase three-wiredistribution system using DSTATCOM', Int. J. Electr. Power Energy Syst.,2011, 33, pp. 1702–1710.

[13] F. Z. Peng and J. S. Lai, "Generalized instantaneous reactive power theoryfor three-phase power systems," IEEE Transactions on Instrumentation andMeasurements, vol. 45, no. 1, pp. 293–297, 1996.

[14] E. D. Watanabe, R. M. Stephan, and M. Aredes, "New concepts ofinstantaneous active and reactive powers in electrical systems with genericload," IEEE Transactions on power delivery, vol. 8, no. 2, pp. 697–703,1993.

[15] B.Singh, K.Al-haddad, A.Chandra, Anuradha and D.P. Kothari, "Threephasecompensator for load balancing and reactive power compensation inthree-phase ,four-wire Electrical power distribution systems", ElectricMachines and Power systems ,Taylor & Francis , pp.27-35, 1998.