Power Quality Problems at Distribution level Under Non linear Loads

Adnan Khan[1], S.M shembekar[2], Dr. P.J Shah[3]

[1](PG Student Electrical Engineering Dept. SSBT's COET bambhori, Jalgaon,(er.adnankhan@gmail.com)

[2](Assist. Professor Electrical Engineering Dept. SSBT's COET bambhori, Jalgaon (smshembekar@gmail.com)

[3](Professor Electrical Engineering Dept. SSBT's COET bambhori, Jalgaon (pjshahj@yahoo.com)

Abstract — **Power quality is focus and area of interest for power engineers nowadays. With the excessive use of advanced and upgraded power electronic equipement, standard system parameters have badly affected. Voltage, current, frequency of system is being subjected to severe changes due to these advancements. Hence to maintain stability of power system new strategies must come into account to cope these issues. Voltage sags and voltage swells have mainly discussed in this paper. And Conventional plus new methods such as Shunt Active Power Filter (SAPF) is proposed as solution and remedy at distribution level.**

Keywords: **Voltage Dips, Swells, UPS, Power Quality, VSC, SAPF**

I. Introduction

Power quality is being a popular, much talked about and considered topic in the performance of many industrial applications such as power system operation, manufacturing units, nuclear and research fields and information technology. Since electrical power occupies the top position in energy hierarchy, power engineers are constantly working in this field. Users require pure sine wave shape, constant frequency and symmetrical and constant voltage with a constant root mean square (RMS) value [1]. To fulfil these demands, the power quality problems must be eliminated from the system. The typical power quality disturbances are voltage sags, voltage swells, interruptions, phase shifts, harmonics and transients. Among the disturbances voltage sag is considered the most severe since the sensitive loads are very vulnerable to momentary changes in the voltage. Voltage sag is a short-duration reduction in voltage magnitude. The voltage temporarily drops to a lower value and comes back again after approximately 150 microseconds[2]. Despite their short duration, such voltage dips can cause adverse problems for a wide range of equipment. The characteristic of voltage sags is related with:

1. The magnitude of remaining voltage during sag
2. Sag duration

In practice the magnitude of the remaining voltage has more influence on system than the duration of sags. Voltage sags are generally within 40% of the nominal voltage in utility. Voltage sags can cost millions of rupees in damaged product, lost production, restarting expenses and danger of breakdown [3][4].

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

There are number of ways to limit the losses and costs caused by voltage dips and one interesting approach considered here is to use voltage source converters connected in shunt across the supply system and the sensitive load, this type of devices are often termed a Shunt Active Power Filter (SAPF).

With the increasing structure of power system in India , the system is becoming giant and complex as a result demand for efficiency, stability and reliability is must. Hence new devices and technology must be introduced to meet all these expectations. In this paper an attempt is made to highlight some of the power quality problems their causes and their consequences on performance of system and hardware. New power electronic device i.e SAPF shunt active power filter is proposed on which we are working to tackle these problems specially voltage sags and swell we are consider [3].

II. PROBLEMS ASSOCIATED WITH POWER QUALITY

a) Transients

When a transmission line is energized by voltage source, the whole of the line is not instantly energized, there is some time difference between initial condition and final steady state condition. This is due to distributed parameters of system such as resistance, inductance and capacitance etc.This is similar to a voltage wave travel along the length of line. This travelling voltage wave is also called surge.

Transients causes oscillations due to digital pulses. Unlike the resistors which responds instantaneously to sudden changes in voltage, inductors and capacitors take time as they absorb and release energy in the form of electrostatic energy and electromagnetic energy. That's why transients are problematic to system performance.

b) Long persisting voltage variations

When RMS (root mean square) values deviations at power frequency last longer than one minute, then we say they are long duration voltage variations. They can be either over voltages, or under voltages. Over voltages is due to switching off a load or energizing a capacitor bank. Also incorrect tap settings on transformers can result in over voltages .under voltage are the results of actions which are the reverse of events that cause over voltages i.e. switching in a load or switching off a capacitor bank.

c) Sustained Interruptions

If the supply voltage becomes zero for a period of time which is greater than one minute, then we say that it is a sustained interruption. Normally, voltage interruption lasting for more than one minute is often unending and requires immediate actions either manually or automatic.

d) Short Duration Voltage Variations

The short duration voltage variations normally occur due to single line to ground and starting of large loads such as IM. The voltage variations can be momentary voltage dips i.e. sag or momentary voltage rise i.e. swells.

i) Voltage sags

Voltage sag is nothing but the momentary decrease in voltage. Voltage sags occur due to system faults and remain for durations from 3 cycles to 30 cycles depending upon the fault clearing time. It is to be noted that under-voltages (lasting less than one minute) can be managed by voltage regulatory equipment. An interruption occurs when the supply voltage or current decreases to less than 0.1p.u for a period of time, less than one minute. Figure 1 shows voltage sag with magnitude and duration. In this paper voltage sag is focused among all other issues related to power quality. And solution is proposed to mitigate this problem along with voltage swell.

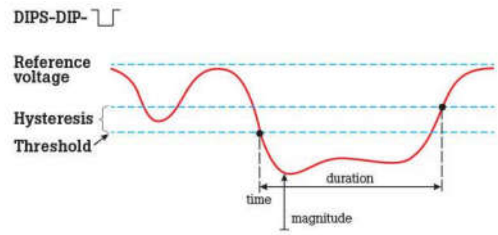

Figure 1

ii) Voltage swell

Voltage swells are opposite of voltage sags and describe surge in voltage of 10% or more above normal that lasts a minute or less. Swells can occur when a large load (such as a large motor) is turned OFF and voltage on the power line increases for a short period of time. Overvoltage is a swell that lasts longer than a minute, sometimes caused when loads are near the beginning of a power distribution system, or if taps on a transformer are set improperly. Figure 2 shows a graph of voltage representing magnitude of swell and duration of swell.

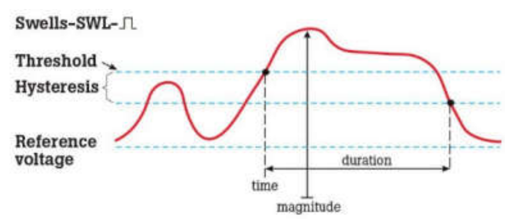

Figure 2

e) Harmonic Distortion

It is expected that the voltage and current waveforms ought to be sinusoidal, but it is not in practice. Pure sine wave is distorted in last 2-3 decades with the inclusion of electronic devices in system. Harmonics are the multiples of sine wave (fundamental frequency).

Harmonics are introduced in the system due to many reasons for example irregularities in flux distribution in alternator, consideration of waveform and form factor are very important AC power transmission but they are more important in case of radio work where signal quality primarily depend upon faithful transmission of harmonic structure of sound waves. Equipment draws more current due to harmonics besides this there are number ways through which harmonics are undesirable in the system.

Figure 3 shows fundamental waveform and distorted waveform due to harmonics.

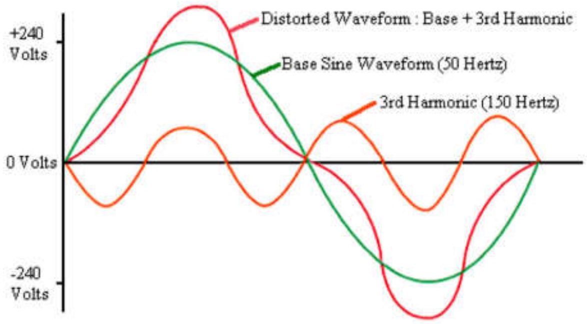

Figure 3

f) Noise

Electrical noise is nothing but unwanted and superimposing currents and voltages that interferes with actual system parameters. It is mainly caused due to interference of electromagnetic waves such as microwaves and its forms. It donot cause major damage to system but loss of data and data processing.

Noise filter or noise suppressor is installed that analyses and supresses unwanted voltage and current of frequency waveforms.Figure 4 shows noise production.

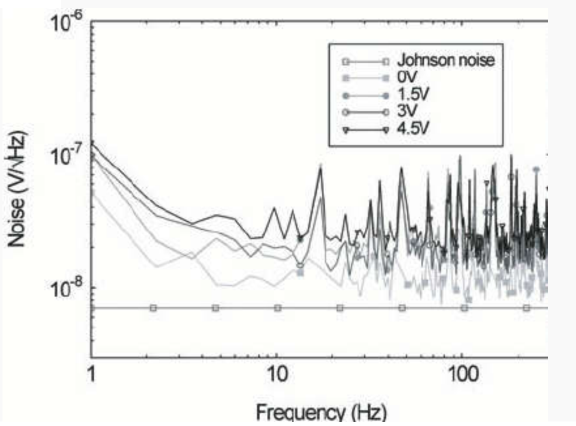

Figure 4

g) Unbalance Voltage

When a three phase voltage carries unequal voltage or unequal phase shift then this type of problem can be regarded as unequal voltage issue. It is mainly due to large single phase loads (welding machines, large electric furnace, or high capacity room heaters) or sometimes even due to faults. Unequal load distribution is also one of the reason for unbalanced voltage in three phase system.

Unbalanced systems imply the existence of a negative sequence that is dangerous to all 3 phase loads. The most affected loads are three-phase induction motors.

Figure 5 shows graph indicating unbalanced voltage waveforms.

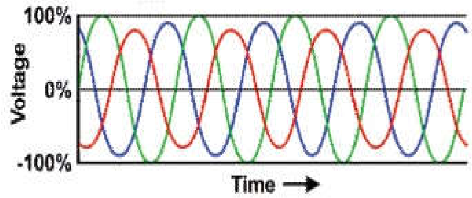

Figure 5

h) Voltage spike

Very fast changes of the voltage magnitude for durations from a few microseconds to few milliseconds can be regarded as voltage spikes. These variations may attain thousands of volts, even in low voltage. The main causes are lightning strokes, switching of lines or capacitor banks used for power factor correction, disconnection of heavy loads.

Destruction of electronic components and of insulation materials, data processing errors or data loss, electromagnetic interference are major reasons. Figure 6 shows such spike generation.

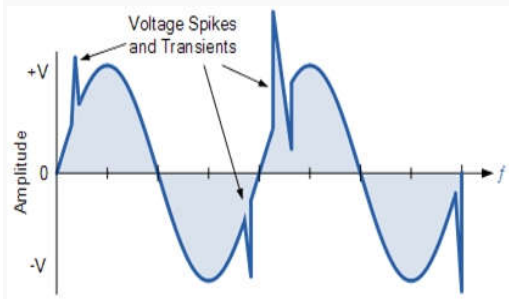

Figure 6

III. CHOICE OF SAPF

Active power filters is the device which generate the same amount of harmonic as generated by the load but 180o phase shifted. So when these harmonics are inserted into the line at the point of common coupling the load current harmonics are eliminate and utility supply becomes sinusoidal. There are basically two types of active filter: Series active filters and shunt active filters. Fig. 7 shows the basic scheme of shunt active power filter which compensate load current harmonics by injecting equal but opposite harmonic compensating current.

There are basically three types of active filters, Series active filter, shunt active filter, and hybrid active filter. The shunt active filter injects proper current to line, while the series active filter injects voltage in the line and hybrid active filter is a combination of both. We are in this paper highlighting Shunt Active Filter, which is more efficient popular and reliable than the series one or hybrid. The main advantage of SAPF is it can be directly connected to grid. Figure 7 shows an AC source connected to a non linear load. SAPF is connected across the line.

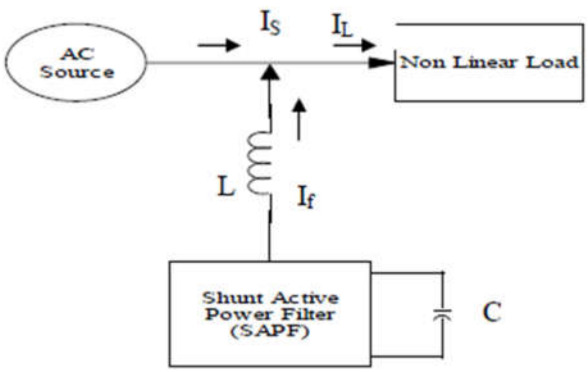

Figure 7

BASIC ARRANGEMENT OF SAPF

The SAPF mainly consist of the following components:

i. PWM Converter
ii. Instantenous Power Calculation block
iii. Reference currents calculation block
iv. DC Voltage regulator

IV. CONCLUSION

In this paper various power quality problems are discussed specially at distribution level and Shunt active power filter is proposed for eliminating the problem of voltage dip, swell and other voltage disturbances in industrial as well as in distribution system. An attempt has been made to demonstrate the issues and solution to these issues. SAPF is mainly focused and discussed. The advantages of SAPF is established both for non-linear loads and induction motor load.

V. REFERENCES

[1] S. Srinath, S. Prabakaran, K. Mohan, M.P.Selvan,"Implimentation of Single phase Shunt Active Filter", 16th national power systems conference, 15th-17th december, 2010.

[2] Moleykutty George and Kartik Prasad Basu," Modeling and Control of Three-Phase Shunt ActivePower Filter", American Journal of Applied Sciences 5 (8): 1064-1070, 2008

[3] *Himabindu.T,"* Performance Of Single Phase Shunt Active Filter Based On P-Q Technique Using Matlab/Simulink", International Journal of Engineering Research & Technology (IJERT), Vol. 1 Issue 9, November- 2012

[4] Donghua Chen, Shaojun Xie," Review of the control strategies applied to active power filters, 2004 IEEE International Conference on Electric Utility Deregulation, Restructuring and Power Technologies (DRPT2004) April 2004 Hong Kong

[5] Bhim Singh, Kamal Al-Haddad, *Senior Member, IEEE*, and Ambrish Chandra, *Member, IEEE,"* A Review of Active Filters for Power Quality Improvement", IEEE transactions on industrial electronics, vol. 46, no. 5, october 1999.

[6] Nagendrababuvasa, Sreekanth G, Narender Reddy Narra, Dr. Srujana A," Series Compensation Technique for Voltage Sag Mitigation", IOSR Journal of Engineering (IOSRJEN), ISSN: 2250-3021 Volume 2, Issue 8 (August 2012), PP 14-24

[7] Hirofumi Akagi, Fellow IEEE," New Trends in Active Filters for Power Conditioning", IEEE Transactions on industry applications Vol. 32, No.6 NOV.1996

[8] Chris Fitzer, Mike Barnes*, Member, IEEE*, and Peter Green," Voltage Sag Detection Technique for a Dynamic Voltage Restorer", IEEE transactions on industry applications, vol. 40, no. 1, january/february 2004

[9] M. Balamurugan, T.S. Sivakumaran, M.Aishwariya Devi," Voltage Sag/Swell Compensation Using Z-source Inverter DVR based on FUZZY Controller", 2013 IEEE International Conference on Emerging Trends in Computing, Communication and Nanotechnology (ICECCN 2013

[10] Miss Dhanshri Sarjerao Pawar, Dr. K Vadirajacharya,"Design of Shunt Active Filter to improve Power Quality using PQ theory",International Journal of Engineering Research and Technology(IJERT), Vol.5 Issue 03, March-2016

[11] R. Sriranjani and S. Jayalalitha," Design of Shunt Active Filter using Iterative method to Mitigate the Harmonics and reactive Power", ARPN Journal of Engineering and Applied Sciences, VOL. 12, NO. 24, December2017

[12] A.Giri Prasad ,K.Dheeraj ,A.Naveen Kumar ," Comparison of Control Algorithms for Shunt Active Filter for Harmonic Mitigation , International Journal of Engineering Research & Technology (IJERT), Vol. 1 Issue 5, July – 2012