International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 4 Issue 07, July-2015

Reduction of Harmonics using Shunt Active Power Filters

S. U. Bhople
Electrical Engineering Department
Mastodary Shikshan Santh's,
College of Engineering and Technology,
Jalna, India

Asst. Prof. Santhosh Kumar Rayarao
Electrical Engineering Department
Mastodary Shikshan Santh's,
College of Engineering and Technology
Jalna, India

***Abstract*— In this paper I given attention on shunt active filter for power conditioning which provide reactive power compensation, harmonic compensation, flicker/imbalance compensation and voltage regulation. This paper deals with different power quality issues and from that harmonics is one of the important issues that affect on equipment connected in our system. The harmonics are introduced because of nonlinear load in system that causes severe damage to power system. Reduction of harmonics is done using shunt active power filter. In shunt active power filter reference current generation is main factor and for that I used techniques like IRP and SRF techniques. In this paper I also paid attention on power quality specially harmonics, its causes, effect and reduction using IRP and SRF techniques.**

Keywords: **Harmonics, IRP, SRF, SAPF, Power Quality, Non Linear load, PCC.**

I. INTRODUCTION

Power quality is defined as any change occurred in voltage, current waveform and frequency deviations that result in damage and failure of equipment connected in system. Power quality block diagram is shown in figure 1. Power quality related problems are of most important a now days. Increased use of electronic equipment, such as information technology equipment, power electronics such as adjustable speed drives (ASD), PLC, energy-efficient lighting, inverter, chopper, cycloconverter, rectifier led to a complete change

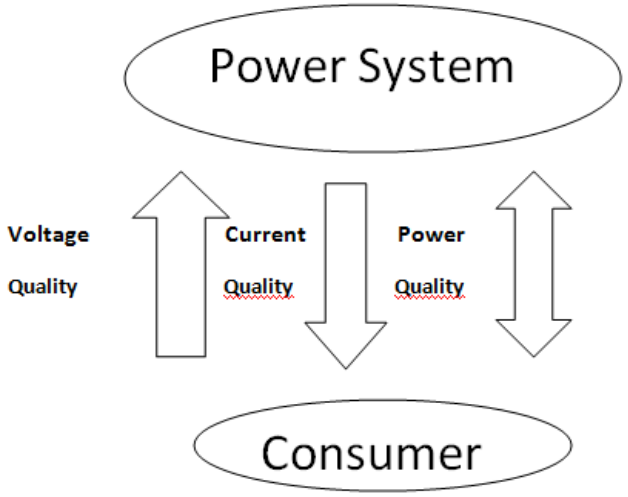

Fig.1 Power Quality

of electric loads nature. These loads are simultaneously the major cause and the major effect of power quality problems. Due to their non-linearity, all these loads cause disturbances in the current waveform. The increased sensitivity of the vast majority of processes industrial and residential led to increased PQ problems in every sector. The most common types of power quality problems are

- Voltage Sag (dip)
- Voltage Swell
- Very Short Interruption
- Voltage Spikes
- Voltage fluctuation
- Noise
- Voltage imbalance
- Harmonic distortion etc.

II. HARMONIC DISTORTION

Definition: According to IEEE standard 1195-1995, harmonics is defined as Voltage or current waveforms assume non-sinusoidal shape. The waveform corresponds to the sum of different sine-waves with different magnitude and phase, having frequencies that are multiples of power-system frequency.

Causes of Harmonics Distortion:

i. Electric machines working above the knee of the magnetization curve (magnetic saturation)

ii. Arc furnaces, welding machines

iii. Rectifiers, Chopper, Inverter, Cycloconverter.

iv. DC brush motors.

v. All non-linear loads, such as power electronics equipment including ASDs, switched mode power supplies, data processing equipment, high efficiency lighting.

Effects of Harmonic Distortion:

i. Increased probability in occurrence of resonance.

ii. Neutral overload in 3-phase systems, overheating of all cables and equipment.

iii. Loss of efficiency in electric machines.

iv. Electromagnetic interference with communication systems.

v. Errors in measures when using average reading meters.

Solution to power quality issues

Above mentioned power quality problem can be solved by using following device

Voltage sag

For protection against voltage sag following equipment's are used

- Install power conditioner at the control circuit (Secondary Equipment AC or DC)
- Dip Proofing Inverter (DPI)
- Voltage Dip Conditioner (VDC)
- Constant Voltage Transformer (CVT)
- Dynamic Sag Corrector (DySC)
- Dynamic Compensator (Dynacom)
- Active Volt Conditioner (AVC)
- Flywheel
- Dynamic Voltage Restorer (DVR) etc

Voltage Swell

For protection against voltage swell following equipment's are used

- Voltage regulators
- Motor – generator set
- Flywheel
- LV, DVR and UPS etc.

Noise

For protection against noise following equipment is used

- Isolation Transformer etc.

Impulses

For protection against Impulses following equipment's are used

- Transient Voltage Surge Suppressors (TVSS)
- Surge Protective Device (SPD)

Under Voltage

For protection against under voltage following equipment's are used

- Voltage regulator
- Motor generator set
- UPS etc.

III. HARMONIC MITIGATION TECHNIQUES.

For mitigation of harmonic following equipment is used

- Harmonic Filter

Following are the two types of harmonic filters

- Passive Filter
- Active Filter

Passive Filter

Passive filters are the oldest type of electronic filter, as they are quite simple, having resistors, capacitor and inductors. The first passive filter of development in the 1880s for telegraphs, but those early years was not exactly successful. This passive filter not powerful enough. The passive filter consist of resistors, inductors, and capacitors, and they do not depend on any type of external power source. In addition, we will find that the passive filters are not going to need to depend on transistors, or other types of active components to work. The inductors and the capacitors work as opposites. The inductors will block high frequency signals and conduct low frequency signals. The capacitors are going to do just the opposite. Because there are been advances in technology and different types of filters on the market, the passive filters might not be in use as much as they were years ago. However, they are still playing a part in many applications. People tend to use passive filter when they want to be able to reduce the amount of harmonic currents, as well as when they need to improve power in the system.

Types of Passive Filter

There are several different types of passive filters in use today. Here are the some common passive filters

- Band Pass Filters
- Power Line Filters
- SAW Filters
- Signal Filters
- Sinusoidal Filters

Advantages of passive filter

The Advantages of passive filter are as fallows

- Simple
- Reliable
- Cost effective alternative but its performance is dependent of the load.

Limitations of passive filter

Passive filter has following limitation

- The performance of passive filter gets affected significantly due to the variation in the filter component values, filter component tolerance, source impedance, and frequency of ac source.
- Passive filter also ngives over compensation of reactive power.
- Passive filter may cause series and load resonances in the system.
- It gets overloaded when the load harmonics increase.
- Passive filter are heavy and bulky.

Due to above mentioned drawbacks harmonic currents can get amplified on the source side and causes serious distortion in the voltage. To overcome the above problems, power engineers developed a solution to power quality problems. Such equipment is called as an active filter and is active filter able to compensate current and voltage harmonics.

Active Power Filter

Sasaki and Machida originally proposed the use of shunt active filters as a method of reducing current harmonics. Recently advances in semiconductor technology have produced high-speed, high-power devices useful for constructing active filters. Active filters of voltage source or current-source inverters provide the necessary compensation of voltages/currents.

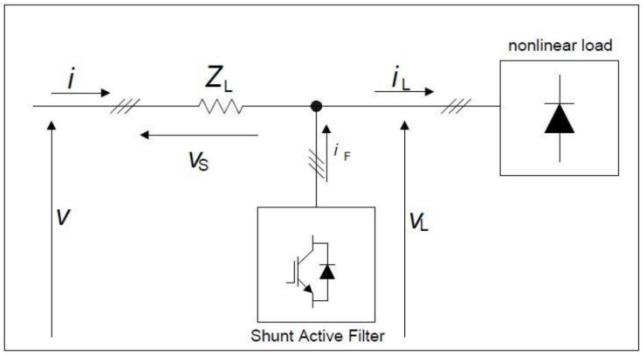

Fig.2 Shunt Active Power Filter

A shunt active power filter (SAPF) generates a harmonic current spectrum that is equal and opposite in phase to the harmonic and/or reactive current it perceives at the load end. Harmonic and reactive currents are thus cancelled at the source end and the resultant is undistorted sinusoidal balanced current. Figure 2 shows the general diagram of of the voltage source shunt active power filter. The active filters are overcome the problem occurring in the passive filter. Main advantage of active filter over passive filter is that it can be controlled to compensate for harmonics in such a way that Total Harmonic Distortion (THD) lower than 5% at the Point of Common Coupling can effectively be achieved. Thus it can prevent harmonic propagation resulting from harmonic resonances. Basically active power filters are used for source current harmonic compensation in supply networks at the low to medium voltage distribution level or for reactive power or voltage control at high voltage distribution level. Active filters of voltage source or current-source inverters basically provide the necessary compensation voltages/currents. The important part of active power filter is reference current generation techniques, on which shunt active power filter (SAPF) generates a harmonic current spectrum that is opposite in phase to the harmonic and/or reactive current it perceives at the load end. Harmonic and reactive currents are thus cancelled at the source end and the result is undistorted sinusoidal balanced currents. As active power filters are used for different purposes this APFs are classified based on the following points

- Power ratings and speed of response requires in compensated system.
- Power circuit configuration and connections.
- System parameter to be compensated.
- Control technique used.
- Technique used to compensate the reference current/voltage

Advantages of Active Filter over Passive Filter:

- It can be used to reduce the effects of harmonics of more than one order
- Voltage regulation
- Reactive power compensation
- Reducing flickering problems
- Damping of power system oscillations
- Also regulates DC link capacitor voltage

Disadvantages of Active Filter over Passive Filter:

- Active filters cost more than the passive filters.
- Active filters cannot be used for small loads in a power system.
- Due to the presence of harmonics in both current and voltage, active filter may not be able to resolve the issue in certain typical applications.
- Active filters cannot be used for small loads in a power system.

For the conditions where both voltage and current are leading to a deterioration in power system, more complex filters are used which are made up of combination of active and passive filters. Such filters are called as hybrid filters.

IV. CONVENTIONAL TECHNIQUES USED FOR HARMONICS MITIGATION.

As we discussed that due to harmonics many problems created and for that shunt active power filter used to solve problems created due to it. In case of shunt active power filter reference current generation is important. Reference current generation is the heart of APF. There are so many techniques for reference current generation. Figure 3 shown below gives basic block diagram of reference current generation. We are using two different techniques here. For reference current generation, active and reactive power is being calculated from three phase currents and voltages. Later on as per control technique power is being transformed. Average power is being calculated from power obtained. Then it is compared with voltage reference obtained from PID controller of inverter. Signals obtained are further compared with source currents. Finally obtained

currents are the reference currents. These reference currents are further given to current controlling circuit for PWM signal generations. Further these PWM signals are given to inverter for harmonic compensation.

Following are the some harmonic reduction techniques

- IRP-Instantaneous reactive power method
- SRF- synchronous reference frame method
- SCM-Symmetrical component method
- STF-Self –Tuning filters method
- PF- Predictive Filtering method

Using all mentioned above reference currents are generated. These reference currents are further used for PWM pulses generation. Figure 3 shown below shows basic control block diagram of SAPF

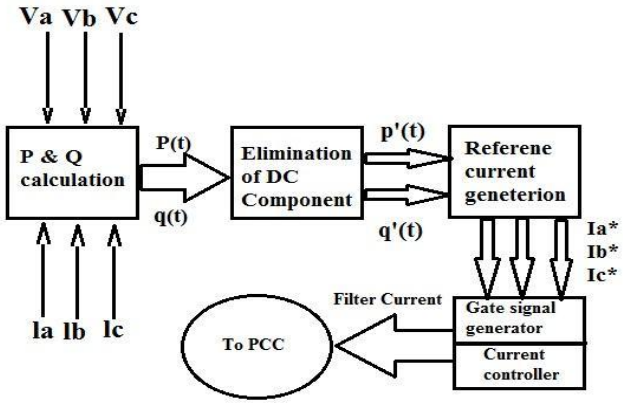

Fig.3 Basic Control Block Diagram of SAPF

III. CONCLUSION

Power quality has many problems and that affect system performance. From that harmonic distortion is one of the important power quality problem that affect on the power system. For reduction of harmonics filter are used. Due to certain drawback of passive filter active filter used for harmonic reduction. In case of shunt active power filter reference current generation is main consideration for that various techniques are used. With the help of this techniques reference current are generated and that fe1d to PCC and thus reduce the harmonic current so that source current to be pure sinusoidal. In this way harmonics are reduced using shunt active power filter.

REFERENCES

[1] Roger C. Dugan, Mark F. Mcgranaghan,Surya Santoso,H.Wayne Beaty "Electrical Power Systems Quality", second edition,Mc Grew-Hill Copy right 2004

[2] Bhim Singh, Senior Member, IEEE, and Jitendra solanki, A Comparison of Control Algorithms for DSTATCOM,IEEE TRANSACTIONS ON INDUSTRIAL ELECTRONICS, VOL. 56, NO. 7, JULY 2009

[3] Hirofumi, Akagi, fellow, IEEE, New trend in active power filter for power conditioning, IEEE,Transaction on industry application, vol 32,No.6,Nov/Dec 1996

[4] M.SUNITHA, B.N.KARTHEEK, Department of Electrical and Electronics Engineering, K L University Vaddeswaram, Guntur, AP, India *Asst Professor Department of Electrical and Electronics Engineering, K L University Vaddeswaram, Guntur, AP, India , Elimination of Harmonics Using Active Power Filter Based on DQ Reference Frame Theory,International Journal of Engineering Trends and Technology (IJETT) - Volume4Issue4- April 2013

[5] N. Srinivasa Rao, H.J.Jayatheertha,M. Tech Associate professor, Department of Electrical & Electronics Engineering, Sri SaiAditya Institute of Science and technology, Surampalem,E.G.District, A.P, India 2Assistant professor, Department of Electrical & Electronics Engineering, Progressive Engineering College, Cheekatimaamidi,Bommalaramaaram(M), Nalgonda District, A.P, India,,MODELING AND SIMULATION OF VARIOUS SRF METHODS FOR SHUNT ACTIVE POWER FILTER AND APPLICATION TO BLDC DRIVE,, International Journal of Advanced Engineering Research and Studies E-ISSN2249–8974 IJAERS/Vol. I/ Issue IV/July-Sept., 2012/18-22