International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 1 Issue 9, November- 2012

Reduction Of Harmonics By Using Active Harmonic Filter

Amit Gupta[1] , Shivani Tiwari[2] , Palash Selot[3]

[1] Assistant Professor, Department of Electrical Engineering, TIETECH, Jabalpur
[2]UG Scholor, Department of Electronics and Communication Engineering, TIETECH, Jabalpur
[3]UG Scholor, Department of Electronics and Communication Engineering, TIETECH, Jabalpur

ABSTRACT

With advancement in technology,there has been an increase in usage of power electronic converters/loads for various industrial applications and process automation.Harmonic distortion is one of the most important problems associated with power quality and creates several disturbances to the Power System. Power electronic loads inject harmonic currents into the utility causing overheating of power transformers. In addition, electric resonances in such loads can also cause other undesirable phenomena like voltage fluctuations, radio frequency interference (RFI) etc. To mitigate these undesirable effects, a new generation of power electronics converter (Active Filters) is being considered.It eliminates the harmonics which are produced through non-linear loads by generating the opposite phase harmonics which gives pure sinusoidal wave.

KEYWORDS:-Harmonic Distortion, Active Harmonic Filter, Non-Linear Loads.

1.INTRODUCTION

Nowadays, it has been an increased concern about the effects of nonlinear loads on the electric power system. The present design trend in electrical load devices is to increase energy efficiency with solid-state electronics. These non-linear loads are any loads which draw current which is not sinusoidal.[1] While nonlinear loads are not new, their increased use means a larger percentage of any power system tends to be nonlinear. One of the major drawbacks of this trend is the harmonics injection to the power system. The effect of harmonics in power system considerably increased due to the use of electronic loads and other high frequency producing devices. With the widespread application of electronics to virtually every electrical load, non-linear loads are also prevalent in commercial and even residential power systems.These loads behave non-linearly towards the power net. Even with a sinusoidal voltage supply, their currents are non-sinusoidal, but still periodically in steady state. Hence they contain other spectral components, the current harmonics, frequencies which are a multiple of the fundamental supply frequency. Harmonic currents adversely affect virtually every component in the power system, creating additional dielectric, thermal, and/or mechanical stresses[2]. The harmonic currents flowing through the power system impedances result in harmonics voltage drops which are observed as harmonic voltage distortion.The wide spread utilization of power electronic devices has significantly increased the number of harmonic generating apparatus in the power systems. This harmonics cause distortions of the voltage and current waveforms that have adverse effects on electrical equipment. The distorted waveform can be a sum of sinusoidal signals. When the waveform is identical, it can be shown as a sum of pure sine waves where the frequency of each sinusoid is an integer multiple of the fundamental frequency of the distorted wave. This multiple is called a harmonic of fundamental. The sum of the sinusoidal is called the Fourier series[3,6].

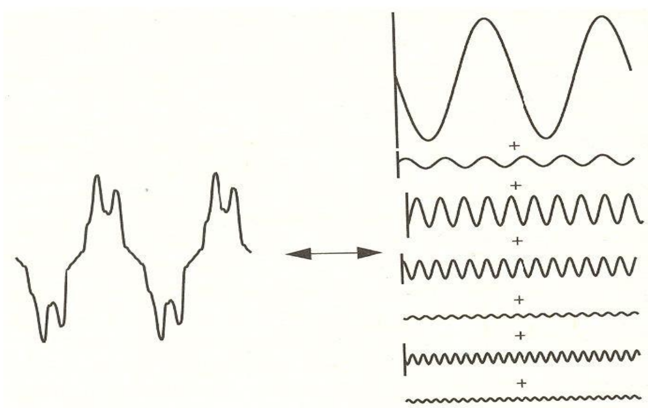

Fig.1 The harmonic distortion produced in sinusoidal wave.

Figure1 shows Fourier series of a distorted waveform. Here the fundamental frequency is the frequency of the power system. That is 50 Hz and the multiples that are 100Hz, 150Hz, 200Hz, 250Hz called second, third, fourth and fifth harmonics respectively. The combine waveform shows the result of adding the harmonic on to the fundamental[4].

Simply stated, harmonic currents are the result of nonlinear loads, in which the resultant current waveform does not conform to the shape of the applied voltage waveform. It is significant that many of the harmonic polluters identified were just beginning to come into their own a decade or two ago.

In general the major types of non-linear loads can be divided into three categories [4].

1. Ferromagnetic devices
2. Arcing devices
3. Electronic equipments.

As the number of harmonic producing loads has increased over the years, it has become increasingly necessary to address their influence when making any additions or changes to an Installation. To fully appreciate the impact of these phenomena, there are two important Concepts to bear in mind with regard to power system harmonics. The first is the nature of harmonic current producing loads (non-linear loads) and the second is the way in which harmonic currents flow and how the resulting harmonic voltages develop.

2.TYPES OF LOADS

There are two types of load. They are classified as follows[5] –

A) Linear Loads

A linear element in a power system is a component in which the current is proportional to the voltage .In the simplest of ac circuits, the ac power source drives a purely resistive load such as an incandescent lamp or resistance heater.

B) Non-Linear Loads

Any type of electrical equipment that changes or modifies the voltage or current waveform to one that is not sinusoidal. The result is a complex waveform consisting of the fundamental plus any harmonic components. As nonlinear currents flow through a facility's electrical system and the distribution-transmission lines, additional voltage distortions are produced due to the impedance associated with the electrical network. Thus, as electrical power is generated, distributed, and utilized, voltage and current waveform distortions are produced. Examples of nonlinear loads include personal computers (PCs), CFL, uninterrupted power supply (UPS) and electronic equipments etc.

3. HARMONIC PROBLEMS AND IMPACT:

(i) Conductor overheating: Conductor heating is a function of the square of the rms value of current per unit volume of conductor. Obviously, an increase in rms current brought on by harmonics results in increased conductor temperature.

(ii) Electromagnetic equipment. Equipment that operates on the principle of electromagnetic induction (transformers, motors, electromagnetic lighting ballasts, solenoids, etc.) is also "double whammied" by harmonics[6,7].

(iii) Power factor improvement capacitors Harmonics can create special problems on circuits containing power factor improvement capacitors. Inductive reactance varies directly with frequency, while capacitive reactance varies inversely with frequency.

(iv) Electronic equipment. Electronic equipment is especially susceptible to both malfunction and damage from harmonics. It is self-evident that electronic component damage can be caused by the additional heating induced by harmonic currents.

(v) Heat losses. Increased losses, in the form of heat that is dissipated in electric equipment, will occur in a plant’s electrical system because of these losses are real energy power losses (kW losses).

(vi) Skin effect. Harmonic currents can cause overheating of conductors and insulating materials as a result of a phenomenon called skin effect. This relates to the increase in AC resistance of a conductor as frequency increases.

(vii) Transformer problems. Waveform distortion will cause increased heating in all types of transformers. This heating is due to an increase in the frequency-dependent eddy current and hysteresis losses. Increased heating can also be expected from skin effect heating in the windings.

(vii) Capacitor problems. Since the impedance of a capacitor is frequency dependent (decreasing reactance with increasing frequency), capacitors will be negatively affected by harmonics. Thus, power factor correction capacitors will appear as very low impedances paths and tend to attract harmonic currents.

(viii) Protective device problems. Thermal over current protective devices, such as fuses and inverse-time circuit breakers, are affected by increased skin-effect heating at the higher harmonic current levels. This excess heating can cause shifts in the devices time-versus-current characteristics, resulting in nuisance tripping. The magnetic trip function of older circuit breakers, whose operation depends on electromagnetic force, is proportional to the square of peak current, not rms current.

(ix) Motor problems. Harmonic voltages and currents will increase the rotor winding and stator winding losses in motors. Since these losses are I^2R losses, increased heating due to skin effect can be expected at the higher harmonic frequencies.

(xii) Electronic equipment operation problems. When the system voltage waveform becomes distorted, electronic equipment also can malfunction. For instance, electronic clocks that count zero-crossings in the waveform may not operate correctly because the distorted waveform provides more zero-crossings than a nondistorted waveform. Thus, these docks will run fast, causing the equipment they control to incorrectly operate.

When the voltage and current are essentially sine waves, and the loads are linear (such as with induction motors, resistance heaters, etc., and via use of transformers), a form of PF is present called displacement power factor (DPF). Today however, many electrical systems also have harmonic currents in their lines. Harmonics are caused by nonlinear or pulsed loads

ISSN: 2278-0181
Vol. 1 Issue 9, November- 2012

(such as electronic power supplies) and their current causes the apparent power to exceed the active power by a substantial amount [9]. In these situations, the form of PF present is called distortion power factor. The sum of the displacement and the distortion PF is the total power factor (TPF). It should be noted that harmonics do not usually show up in kW, which is the reason harmonics tend to reduce TPF. In an electrical system, the harmonic currents caused by nonlinear loads may cause TPF to be low (0.6 to 0.7) while the DPF could be relatively high (0.9 to 0.95). Because of the abundance of nonlinear loads now being placed on lines, PF must now be looked upon as being the total power factor [7].

4. METHODS FOR REDUCTION OF HARMONICS

Filtering is an method to reduce harmonics in an industrial plant when the harmonic distortion has been gradually increased or as a total solution in a new plant. There are two basic methods: passive and active filters.

a.Filtered Automatic Power Factor Correction Units (FAPFCU).

The filter consists of several capacitor and inductor circuits (stages) which are switched on or off by an electronic power factor controller. The more load which is running, the more filter stages will be switched on by the controller. This filter is effective for generator applications as a leading power factor can be avoided.

b. Drive Filters.

This type of filter will provide power factor correction but if the capacitor inductor circuit is oversized there is a greater risk of leading power factor at low loads, particularly with voltage source drives. This filter is very effective in providing severe harmonic reduction.

c. Active Harmonic Filters.

This is new technology. Creates harmonics to compensate for both import and export harmonics. Typically these filters are sized based on how much harmonic current the filter can produce, normally in amperage increments of 50 Amps. Once the amount of harmonic cancellation current is determined the proper amperage of active filter can be chosen. From given above different techniques for harmonic reduction we are using active harmonics filter .As it is a best and latest technology .

5. AN APPROACH FOR ACTIVE HARMONICS FILTER

The active filter is the newest technology of all types of filters, and due to the highly electronic nature is considered reliable. Active filters do not provide voltage support at high load. They will provide voltage support at low loads, typically when voltage support is not required.[11] Active filters are inherently non-resonating and are easily connected in parallel with system loads Active Harmonic Filter is based on the principle with a real-time measuring device and will actively generate a harmonic current spectrum in opposite phase to the measured distorting harmonic current for cancellation.

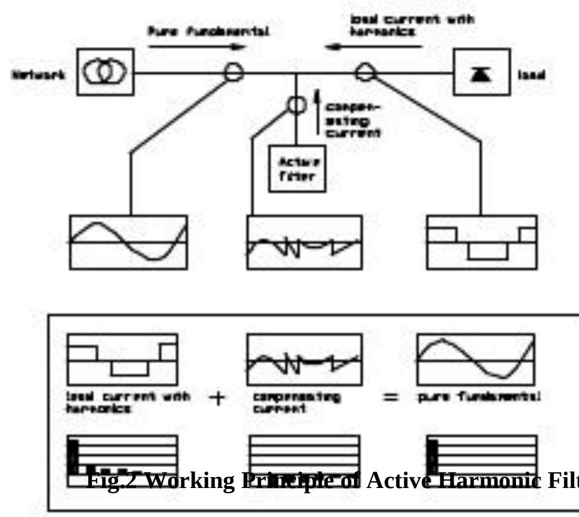

Fig.2 Working Principle of Active Harmonic Filter

Series active filters are connected in series with the network and compensate harmonic voltages by adding voltages to the network as a counter measure. This kind of filter is often placed at a central point to isolate two areas, this means that the network voltage at one side of the filter can be of a different pollution then the other side. However this can only work well if the non-linear loads in the network find a current path nearby. As explained before, nonlinear loads can be modeled as linear loads with a parallel current source for each harmonic.

If there is no path provided for these harmonic currents in the surrounding area, the current will propagate through the series filter to a wider area. For a good control of harmonics therefore, series active filters can be best combined with shunt active or passive filters.Shunt active filters are connected in parallel with the network and compensate harmonic currents by injecting currents to the network as a counter-measure. For this function, the best location of the shunt active filter is nearby a polluting load.

6. ACTIVE HARMONIC FILTER OPERATION

Very different control algorithms can be applied to the active filter, . The developed control system is based on a direct current control strategy that generates the reference waveform for the source current. It requires a low processing time and allows the calculation of the current reference for one of two strategies,:

ISSN: 2278-0181
Vol. 1 Issue 9, November- 2012

1- Power factor correction, harmonic elimination, and load unbalance compensation, or

2- Voltage regulation, harmonic elimination, and load unbalance compensation.

The control algorithm needs the measurement of several variables like the three phase AC source voltage and the DC link voltage. The active power balance in the DC link determines the reference current of the AC source and the use of a PI controller allows a smooth control of the filter current and improves the system dynamic response[13].

The Active Filter is connected in parallel with the AC line, and constantly injects currents that precisely correspond to the harmonic components drawn by the load. The result is that the current supplied by the power source remains sinusoidal

I load = I fundamental + I harmonic

I correction = I harmonic

I load = I source + I correction

Then, the source supplies the load with the fundamental component of the current only.

The normal power source provides the fundamental current, and the Active Harmonic Filter (AHF) supplies the harmonic currents required by the load. The entire low-frequency harmonic spectrum (2nd – 25th and can be extended to 50th) is injected. If the harmonic currents drawn by the load are greater than the rating of the Active Harmonic Filter, the filter automatically limits the injected current to its rated output current.[13]

It is easy to implement, an active filter may be installed at any point on a low voltage AC system to compensate the power drawn by one or several non-linear loads, thus avoiding the circulation of harmonic currents throughout the low-voltage AC system.Displacement phase angle between current and voltage was about ¼ cycle, this implied the reactive energy consumed by the system and poor power factor lagging.

The input voltage Vs(t) presents a large total harmonic distortion. But the total harmonic distortion of the output voltage, compared to the input voltage, is much less . Once more, this shows a good and an appropriate action of the series active filter.

A simple circuit would regulate a load such that the current presented to the source resembles that of a sinewave i.e. while the non-linear load is not drawing current i.e. ahead and after the peak, the active control draws current on the load's behalf (in the correct proportion) such that the current draw on the source appears 'linear'. However, this would result in a lot of heat loss for no true benefit.

With "distortion management and mitigation", the oldest scientific principle comes into play. "for every action there is an equal and opposite reaction". A derivative of this is "an action can be nulled by an equal and opposite action", and this is exactly how 'active harmonic control' operates[10].

The initial problem is the inductive load draws current at the wrong time on the cycle (if purely inductive, the highest current occurs at the zero crossing after the peak voltage). To correct

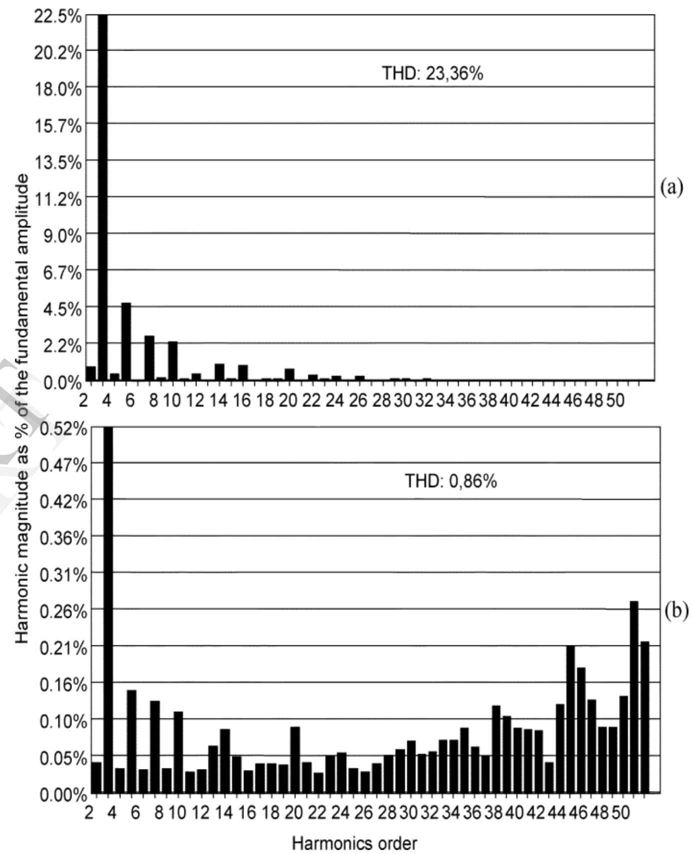

Fig.3 THD before and after use of AHF

With active control, the 'filter' does exactly the same thing. It's actually quite simple; It uses the time the non-linear load is not drawing current to charge a capacitor. The moment the load starts drawing current, the capacitor is used to augment the supply. The result is the load presented to the supply begins to resemble a linear load - the process being done with high-speed switching techniques.

Normal non-linear (hi-tech) loads demand energy not just at the fundamental, but at a number of harmonics too. The active harmonic filter, by generating the harmonic energy in the correct proportions, relieves the source of this burden leaving it to supply the needed energy at one frequency only - the fundamental.

The great thing about active filters is they are based on phase locked loops and therefore track the incoming frequency (the failing of many an LC filter).[8] They also adjust the conversion (harmonic generation) to the ever changing load so the supply always thinks the load is nothing but nearly resistive.

This apparently perfect solution does come with a few warnings though. They are built with complicated technology and can, therefore, break down.

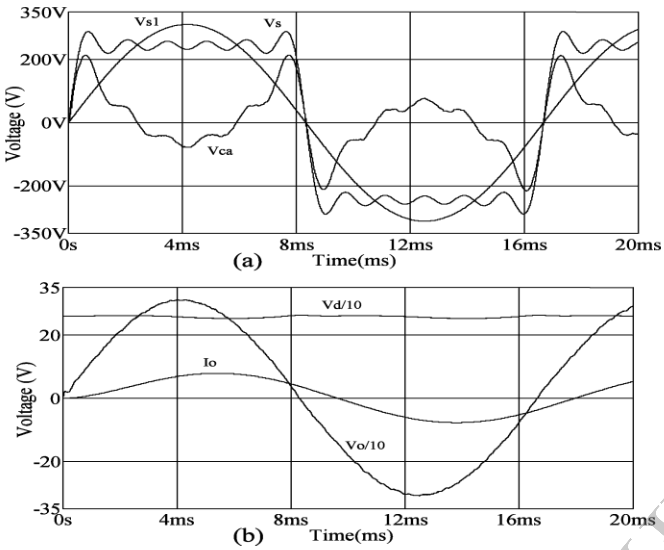

Fig.4 Cancellation of harmonics producedin system

They do need a little energy to run, and the conversion process is about 97% efficient. The operating energy varies between makes, but is usually about 200-500W, and the conversion process will usually dissipate about 3% of the total harmonic energy being combated e.g. if the harmonic content is, say, 100A @ 230V, the device will emit approx 700W heat over and above its running energy.

7. CONCLUSION

The harmonic distortion produced causes ample of problems in the circuit and can cause severe damage to our system. It give its effect on components of circuit in which it get introduced.This paper represents the latest technology i.e. active harmonic filter which is the best way to reduce the harmonics distortion produced due to different non linear loads and how it is more efficient than other techniques. This technique gives the best result as it detects the minor change in current or voltage. The other filters are not compatable for general purpose whereas thisfilter is compatable in nearly every aspects and are widely used around the world. They are not for lower impedance circuits. It also shows the total harmonic distortion before and after the use of active harmonic filter.the two basic techniques which are use for this purpose are series active filter and shunt active filters.

8. REFERRENCES

[1] Palko, Ed. "Living with power system harmonics." Plant Engineering, 46.11 (1992). Info.Trac Engineering Collection.

[2] "Effects of **Harmonics** on Power Systems," Parts 1 and 2, October '95 and February '96 issues respectively; "Using the Right Meter for Power Quality Troubleshooting," October '95 issue.

[3] Lemerande, Cory J. "Harmonic distortion: definitions and countermeasures." EC&M Electrical.

[4] www.**power**studies.com/articles/Harm_Introduction.

[5] 10. Waggoner, Ray. "How harmonics affects power factor." *EC&M Electrical Construction & Maintenance* 92.10 (1993).

[6]. Hands-on approach to solving harmonic problems - Parts 1 and 2", March, April '90 issues; "Coping with phase-to-phase nonlinear loads and **harmonics**", June, '91 issue.

[7] Peterson, Craig D. "Harmonics for nonelectrical engineers." *Plant Engineering* 48.16 (1994):

[8] Enio R. Ribeiro, Member, IEEE, and Ivo Barbi “Harmonic Voltage Reduction Using a Series Active Filter Under Different Load Conditions” 5,september2006. , Senior Member, IEEE transactions power electronics

[9] Adam Dabrowski,Krzyszt Control Circuit for Active Power-Harmonic-Compensation Filter in Power Systems – Realized with Digital Signalsozanski porzan university of technology institute of electronics and telecommunication division for signal processing and electronic system.

[10] Zainab Nadhem Abbas Al-Mousaoy, Effect of Non-Linear Load Harmonics on Single phase Transformer Losses and Design Active Filter

[11]
Ir K F Yei" Energy Efficient Initiative Installation of Active Harmonic Filter and RealTime Capacitor Bank in High Speed Lift System."RSO, RSExecutive Committee Member B SOMES)

[12] P.J.M. Heskes, J.M.A. Myrzik, W.L. Kling
Survey of Harmonic Reduction Techniques Applicable as Ancillary Service of Dispersed Generators (DG).

[13] www.activeharmonicfilters.com