International Journal of Electrical and Electronic Engineering & Telecommunications

ISSN 2319 – 2518 www.ijeetc.com
Vol. 4, No. 4, October 2015

Research Paper

HARMONIC REDUCTION SYSTEMS USING ACTIVE AND PASSIVE FILTER

M M Share Pasand[1]*

*Corresponding Author: M M Share Pasand, ✉ sharepasand@standard.ac.ir

The world has emerged as an era of electronics in recent ages with functioning systems being quite dependable on electronics and machinery. The emerging usage of electronic switching systems caused some power quality issues, specially harmonic pollution which results in several problems in the distribution system as well as sensitive electronic devices. In this paper we analyzed the ongoing problems in power systems and the role of harmonics in it while putting a light on the role play of active and passive power filters in harmonic reduction for quality assurance in electronics. Harmonics put a great impact on the functioning of power systems which can be controlled by harmonic reduction process while using active and passive power systems effectively.

Keywords: Power systems, Harmonics, Active power filters, Passive power filters, Total harmonic distortion

INTRODUCTION

In recent ages due to increasing use of electronic equipments harmonics are considered as one of the major problems in electrical and electronics engineering and there has been so much work going on to develop such a solution for better harmonic control to provide enhanced power quality (AcunÞa *et al.*, 2012).

Harmonic control is of vital importance since, low power quality may result in several problems including saftey hazards caused by overheated components of a circuit, compatibility problems between different components connected to a shared bus, distribution losses, damage to several components such as transformers, power switches and electric motors, accidental operation of remotely controlled swithes and breakers (false tripping), equipment malfunction due to excess voltage, metering errors in power distribution and distributed measurement and control systems, fires in wiring, penalties on monthly bill units, generator failures, etc.

[1] Standard Research Institute, Alborz, Iran.

There are two categories of solutions to harmonic problems including preventive and remedial (George, 2001). Preventive solutions are those policies that focus on aims to avoid harmonics and their subsequent consequences by doing phase cancellation in power converters and developing such methods to reduce, control, and eliminate the element of harmonic distortion in power system equipments such as transformers, generators, and capacitors. Corrective solutions are those that include use of filters and circuit detuning through relocation of capacitors and reconfiguration of feeders to overcome resonance (George, 2001).

For the purpose of harmonic reduction power filters are increasingly being used in systems either the active or the passive ones as they provide with quality control methods (Jarupula, 2012). However, just as there are great benefits of these filters in harmonic reduction there also exist some de-merits of both the types. Passive harmonic filters are largely used conventionally with some de-merits such as bulk, tuning problems, resonance, noise, increased compensation and fixed losses for which active power filters can be used to overcome these problems (Pietkiewicz, 2008). In this paper we will discuss the role of these two types of filters in reduction of harmonics in power systems in the light of various previously carried researches and their subsequent results (ABS, 2006).

MATERIALS AND METHOD

Literature Analysis: The research was undertaken by reviewing the published articles on harmonic reduction using active and passive filters since 2000. The following search terms were used: (1) harmonics, harmonic reduction, and (2) active filters for harmonic reduction, passive filters for harmonic reduction, harmonics of power systems. The cites that were searched include IET Power Electronics, *Tamkang Journal of Science and Engineering, Eaton Powerware*, International journal of advanced scientific research and technology, *Journal of the Chinese Institute of Engineers*, Schaffner EMV AG, IEEE Transactions on Industry Applications, International Journal of Modeling, Springer, *International Journal of Electrical Power & Energy Systems*. The sorted results were first evaluated on the basis of their respective titles and abstracts and afterwards complete text of the selected published study was obtained on the basis of selection criteria as described below. Proper literature analysis was done with analyzing scales. Abstract-only studies, letters, reviews of authors, and case reports were excluded from the search.

Selection of Study: Studies conducted power system harmonics were selected and reviewed. Only studies based on the role of power system active and passive filters for harmonic reduction were selected. Studies were critically meta-analyzed and reflected. Study type including cross-sectional, case control, or cohort design was included. The studies that mentioned the current issue of harmonics in power systems along with those showing the role of active and passive filters to overcome the problem were selected to collect data from.

Data Collection and Quality Assessment: Data showing significant role of active and passive filters in harmonic reduction was

extracted, evaluated and analyzed from the selected studies to achieve the understanding for the current issue related to system harmonics if present and the role of filters to control this problem. Data extracted was recorded as per first author's last name, the year of publication, and the region in which it was carried. Harmonics was defined as per *International Journal of Electrical Power & Energy Systems* on the basis of wave frequencies and their fundamental frequencies. Similarly, data related active and passive filters use was sorted and critically analyzed to evaluate their role in power system harmonics. Quality assurance was undertaken while using Newcastle-Ottawa Scale grading as being low, intermediate, or high quality as defined by scores of 1-3, 4-6, and 7-9 in that order.

Statistical Analysis: Statistical analysis was done while searching for global statistics on the relevant data on power system harmonics and the use of filters. Result from each study was gathered by performing meta-analysis so as to be more appropriate both statistically and mechanically. Meta-analysis was done using Comprehensive Meta-Analysis software, Version 2.2 to find the role of filters in reduction of power system harmonics. Cross-sectional investigations on large samples, approaching studies and systematic reviews were compared for global statistics on power system harmonics and filter use so as to reflect the results in this paper. Current analysis was done according to the guidelines of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) and Meta-Analysis of Observational Studies in Epidemiology (MOOSE).

RESULTS

Most of the power systems have ability to accommodate some certain level of harmonic currents beyond which the system will experience problems when harmonics become quite a significant component of the overload. For this purpose active and passive filters prove to be effective in reduction of harmonics with some advantages and disadvantages (Eaton Powerware, 2010). Active filters are usually installed in parallel to power line and requires external power source whereas passive filters may be used in series or [parallel and do not require external power source (Kumar *et al.*, 2006). The magnetic component of active filters provides high quality harmonic reduction than the passive filters which are in comparison to active filters are quite conventional and economical. For this purpose active and passive filters play quite a significant role in the reduction of harmonics while providing better quality power systems and satisfy the safety concerns of the customers with a minimum purchase and installment cost (Rastogi *et al.*, 1994).

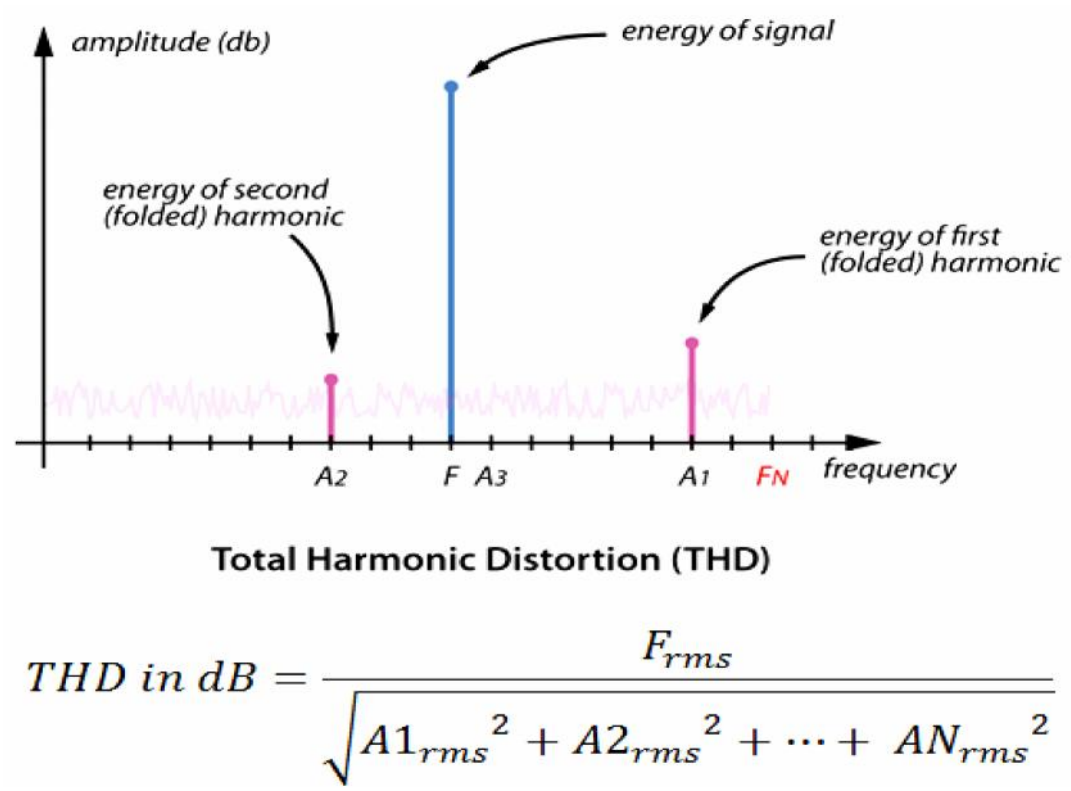
Harmonic Filters

The harmonic distortion can be reduced efficiently using a passive filter (Figure 1) which is a series of capacitor and reactor combined to tuned to a specific harmonic frequency. These filters have low impedance to harmonics with zero impedance at tuning frequency (Hsiao, 2001). A major purpose in designing a filter for harmonic reduction is to keep Total Harmonic Distortion (THD) to a level below 5% to get the maximum benefit from the filter (Wakileh, 2001).

Active Harmonic Filters

As stated by Pietkiewicz in 2008 the active

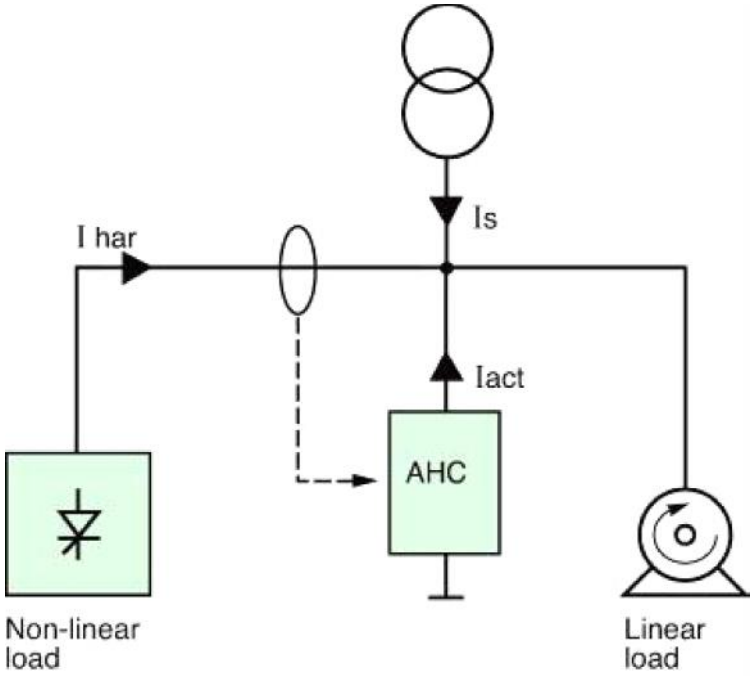
Figure 1: Total Harmonic Distortion



Total Harmonic Distortion (THD)

$$THD\ in\ dB = \frac{F_{rms}}{\sqrt{A1_{rms}{}^2 + A2_{rms}{}^2 + \cdots + AN_{rms}{}^2}}$$

Figure 2: Harmonic Load



harmonic filters are mostly installed in parallel to power line with shunt filtering effect and they demand magnetic components on the load for economic reasons (Figure 2). If no magnetic fields are implied then the required corrective current would have to be kept high which requires significantly oversized active filters (Pietkiewicz, 2008).

Passive Harmonic Filters

Passive power filter is a type of harmonic filter which only demands passive elements to be constructed. It requires linear setup of elements such as resistors, capacitors, and inductors. A passive filter has many advantages over an active filter such as guaranteed stability, no power consumption, inexpensive, and conventional. For the purpose of harmonic control use of passive filters has been quite effective. In one study by Wei-Hsiang Ko in 2013 it was shown that a detuned passive filter was not capable of providing the system with effective harmonic reduction while the filter which was single tuned effectively reduced harmonics along with the amplification of the parallel harmonics too but the additional power loses were not economical (Wei-Hsiang Ko, 2013).

Hybrid Harmonic Filters

The hybrid power filter is a combination of active and passive power filters and is further classified into two more types including hybrid active power filters in parallel (PHAPFs) and hybrid active power filters in series (SHAPFs) depending upon the type of active filter used. This method of harmonic reduction is quite promising in output relative to low capacity active power filters. For the purpose of harmonic current tracking control two effective plans are available including the linear current control system and the non-linear current control system. The example of the first one is that of deadbeat control, ramp comparison control, etc., and that of the second one is predictive control and hysteresis control. Jarupala in 2012 proposed that hysteresis control has some advantage of simplicity but at the same time it results in varying switching frequencies in a wide range. This limitation of hysteresis control has been overcome while implementing variable band switching hysteresis which in turn requires a complex control system for good performance (Jarupula, 2012).

CONCLUSION

The globalization has brought a great change in electronic dependency with increasing use of machinery and power systems in our society to provide us with modern lifestyle. This has put a great challenge to the world of electronics. Power systems being the main play of electronic industry demands high quality management of designing for which purpose harmonic reduction in power systems has a significant place. The active and passive filters play quite an important role in reducing system harmonics for better quality function.

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