A Review on Mitigation of Harmonics Distortion in the Power Grid

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ABSTRACT
Any research work foundation depends on literature survey. Based on the studies carried out by several researchers and their contribution to research field motivates for further scope of research. The power quality issue has recently augmented because of the increased use of power electronics equipments, which results in a voltage deviation and current waveforms. In this article a review of techniques and methodologies developed for power quality analysis is presented in order to show their characteristics.

Keywords: - Harmonic, Power quality, EPQ etc..

INTRODUCTION

Electric Power Quality (EPQ) has different meanings to different people. The definition of power quality given in the IEEE dictionary originates in IEEE Std. 1100: “Power quality is the concept of powering and grounding sensitive equipment in a matter that is suitable to the operation of that equipment.”

However there is no single definition of the term “power quality”. Another description is : “Power quality is the provision of voltages and system design so that the user of electric power can utilize electric energy from the distribution system successfully, without interference or interruption.” The next explanation is “Power quality is the combination of voltage quality and current quality. Thus power quality is concerned with deviations of voltage and/or current from the ideal.” On the other hand, power quality problems are described in the following way: “A power quality problem exists if any voltage, current or frequency deviation results in a failure or in bad operation of the customer’s equipment. The quality of the power supply consists basically of two elements, the supply reliability and the voltage quality.” Based on the previous descriptions it can be concluded that the concept “power quality” involves two parties: the supplier of the electricity and the user. The “power quality” can then be regarded as a measure of purity of the energy which is transferred from the supplier to the user.

Current quality is concerned with deviations of the current from the ideal. The ideal current is a single-frequency sine wave of constant frequency and magnitude. An additional requirement is that this sine wave is in phase with the supply voltage. Thus where voltage quality has to do with what the utility delivers to the consumer, current quality is concerned with what the consumer takes from the utility. Voltage and current are strongly related and if either voltage or current deviates from the ideal it is hard for the other to be ideal. Voltage quality is concerned with deviations of the voltage from the ideal. The ideal voltage is a single-frequency sine wave of constant frequency and constant magnitude. The term voltage quality can be interpreted as the quality of the product delivered by the utility to the customers. Power quality problem is defined as any power problem manifested in voltage current or frequency deviations that result in failure or missoperation of customer equipment. The power supply system can only control the quality of the voltage, it has no control over the currents that particular loads might draw. Therefore, the standards in the power quality area are devoted to maintaining the supply voltage within certain limits. Any significant deviation in the waveform magnitude, frequency or purity is a potential power quality problem. Of course, there is always a close relationship between voltage and current in any practical power system. Although the generators may provide a near-perfect sine-wave voltage, the current passing through the impedance of the system can cause a variety of disturbances to the voltage. Power quality is often considered as a combination of voltage and current quality. In most of the cases, it is considered that the network operator is responsible for voltage quality at the point of connection while the customer’s load often influences the current quality at the point of connection.

II BACKGROUND

Generally, electrical engineers are focused on the subject of generation, transmission, distribution and utilization of electric energy. The distribution system is a vital connection between the generation and utilization of electrical power at rated amplitude and frequency, which indicates the Electric Power Quality (EPQ) [1]. EPQ is often used to express voltage as well as current quality, reliability of service, and quality of power supply, etc. Poor power quality sources are raised from two categories: (i) Non-linear loads, electrical components and equipments (ii) Subsystems of transmission and distribution systems. Quality degradation of electric power mainly occurs due to power line disturbances such as impulses, notches, voltage sags / swell, voltage and current unbalance, interruption and harmonic distortions [2]. The electric power quality has become an important part of the distribution power system. Harmonics are the primary cause for the poor power quality of the distribution system. Harmonics are qualitatively defined as sinusoidal waveforms having frequencies that are integral multiples of the power line frequency. In power system engineering, the term harmonic is widely used to describe the distortion for voltage or current waveforms [3]. The power line frequency (fundamental) is 50 Hz or 60 Hz. In case the fundamental frequency is 50 Hz, then 5th harmonic is 250 Hz, and 7th harmonics is 350 Hz, etc. Nonlinear loads are the main source of harmonic related problems. All electronic loads are mostly non-linear and generate harmonics in the power system. These non-linear loads draw only short pulses of current from supply network and combine with the source impedance resulting in distortion of the supply voltage [4]. The modern power electronics provide suitable topology to mitigate the power quality problems [5]. This chapter discusses the harmonic distortion and its solutions based on shunt active power line conditioner.

AC power supply feeds different kind of linear and non-linear loads. The non-linear loads like power converters and solid state drives that use high speed switches are the main sources of harmonics in the power system [6]. The harmonics in the system induce several undesirable issues; such as increased heating in transformers, low power factor, torque pulsation in motors, overvoltage by resonance, and harmonic voltage drop across the network impedance, poor utilization of distribution plant and also affects other loads connected at the same Point of Common Coupling (PCC).

Traditionally, passive filters have been used to compensate the harmonic distortion in the distribution system. Passive filters consist of inductive and capacitive elements and are tuned to control harmonics. The passive filter is connected in shunt with the distribution system and is tuned to present low impedance to a particular harmonic current. However, it is found that the passive filter is not commonly used for low voltage or medium-voltage applications since the complexity and reliability factors are matters of concern. It also inherits several shortcomings such as ageing and tuning problems, resonance that affects the stability of the power distribution systems, bulky in size and also fixed compensation [7]. To solve these problems, different configurations of Static VAR Compensators (SVCs) have been proposed.

Unfortunately some SVC generates lower-order harmonics themselves and the response time of the SVC system may be too long to be acceptable for fast-fluctuating loads. Recently, Active Power Filter (APFs) or Active Power-Line Conditioners (APLCs) are developed for compensating the harmonics and reactive-power simultaneously [8]. The APLC topology can be connected in series or shunt and combinations of both (unified power quality conditioners) as well as hybrid configurations [9-11]. The shunt active power line conditioner is most commonly used than the series active power line conditioner, because most of the industrial, commercial and domestic applications need current harmonic compensation.

III HARMONICS IN POWER SYSTEM

The various standards and guidelines have been established that specify limits on the magnitudes of harmonic currents and voltages. The Comite Europeen de Normalisation Electrotechnique (CENELEC), International Electrotechnical Commission (IEC), and Institute of Electrical and Electronics Engineers (IEEE) specify the limits on the voltages at various harmonic frequencies of the utility frequency [13].

In 1983, IEEE Working Group made a reference about harmonic sources and effects on the electric power system. There is significant activity in the IEEE-Power Engineering Society and IEEE-Industry Applications Society to detect harmonic effects. These societies and institutes define standards for harmonics [14]. T.C.Shuter surveyed and reported the harmonic levels (three classes of distribution circuits; residential, commercial and industrial) in the American Electric Power Distribution System [15].

Christopher reported the statement “The Static Power Converter Committee of the Industry Applications Society recognized the harmonic related problems and started work on a standard that would give guidelines to users and engineer-architects in the application of static power converter drives and other uses on electric power systems that contained capacitors. The results was IEEE 519-1981, IEEE Guide for Harmonic Control and Reactive Compensation of Static Power Converters” [16].

Joseph mentioned about harmonics-causes, effects, measurements, and analysis with Specific system in the cement, steel and carbon industries [17].

Alexander E. Emanuel surveyed the harmonic voltages and currents at the customer point of industrial, commercial and residential applications [18].

In 1996, IEEE working group proposed definitions for power terms that are practical and effective when voltage and/or currents are distorted and/or unbalanced. It also suggests definitions for measurable values that may be used to indicate the level of distortion and unbalance [19].

Eric J. Davis reported the harmonic pollution metering as a theoretical consideration. He advocated “Toll Road” concept: this method requires each consumer to pay according to the amount of stress (usage) his equipment causes to the mitigation equipment [20].

Jacques discussed the concept of apparent power in single-phase sinusoidal and unbalanced three-phase situations under IEEE Standard 1459-2000. Here power factor is defined as the ratio of the actual active power to the apparent power in the power system [21].

Salvador noticed about IEEE Standard 1459. It includes new definitions for the measurement of electric power quantities under sinusoidal, non-sinusoidal and balanced or unbalanced conditions [22].

Predrag reported about power components estimation according to IEEE Standard 1459–2010 under wide-range frequency deviations. This statement clarifies using adaptive phase shifter, cascaded integrator–comb filter, finite-impulse-response comb filter, algorithm [23].

Yao Xiao described the harmonic summation method for the standard IEC / TR 61000-3-6 in the power system [24].

The IEEE standard 1459 is intended to evaluate the performance of modern equipment or to design and build the new generation of instrumentation for energy and power quantification.

IV PROBLEM FORMULATION

There is an increased concern of power quality due to the following reasons:

- New generation loads that uses microprocessor and microcontroller based controls and power electronic devices, are more sensitive to power quality variations than that equipments used in the past.
- The demand for increased overall power system efficiency resulted in continued growth of devices such as high efficiency adjustable-speed motor drives and shunt capacitors for power factor correction to reduce losses. This is resulting in increasing harmonic level on power systems and has many people concerned about the future impact on system capabilities.
- End users have an increased awareness of power quality issues. Utility customers are becoming better informed about such issues as interruptions, sags, and switching transients and are challenging the utilities to improve the quality of power delivered.
- Most of the networks are interconnected these days. Integrated processes mean that the failure of any component has much more important consequences.

V PROPOSED WORK

Shunt active power line conditioner uses power electronics to produce complementary harmonic components that compensates the harmonic components produced by the non-linear load. This harmonic filter consists of a power converter unit and control unit, which controls the harmonic injection of the filter into the ac network based on the measured load harmonics. Therefore, this device senses voltage and current harmonics and generates offsetting harmonics to cancel out the superfluous harmonics in the source. There obviously exists a feedback mechanism by virtue of which the source provides clean waveforms for the load. Voltage regulation and power factor control are also normal byproducts of this filter operation. Some of the merits of using active power line conditioner are [25]

- Harmonic reduction
- Reduction of three-phase neutral return current
- Impact minimization upon the distribution transformer
- Power factor improvement
- Voltage regulation
- Automatically adapts to changes in the ac network and load fluctuation
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  liminating risk of resonance between filters and network impedance

Figure 1 shows the proposed work of our thesis. In this we have to setup an APLC between source and non linear load. The source produce sinusoidal wave which is distorted by the non linear load. The non linear load gives the harmonic contents in the supply. The APLC is used to compensate the load current.

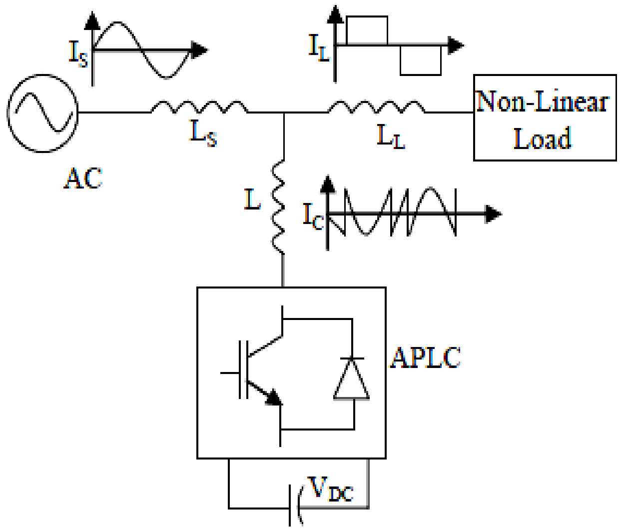

Figure 1 Single line diagram of APLC connected system.

VI CONCLUSION

Electrical system reliability and normal operation of electrical equipment rely heavily upon a clean distortion free power supply. Because of the number and variety of available methods, selection of the best technique for a particular application is not always an easy or straightforward task. This article deals the different work associated with the different researchers in the field of harmonics distortion. It also provides the basic problem associate in the work and presents a new method for mitigation of the harmonics with an easy approach.

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