A Review on Distribution System with Harmonic Reduction

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Abstract - In the world of electrical power generation, a main point of consideration has always been to achieve adequate performance in terms of power quality. In this context, an important factor is the generation, management and reduction/compensation of spatial and time harmonics throughout the whole power system. From the first developments in the mid-1800s of electrical power generation and distribution systems, harmonic content improvement and reduction has evolved from a localised generator design problem to an internationally regulated supply characteristic that must be considered at all points of the power distribution network. This paper is thus aimed to be a review of harmonic improvement techniques and methodologies, organised to follow and indicate the development timeline of these methods. Distribution level generation has been chosen as the focus to align with recent changes in grid topology caused by distributed and renewable generation. In this section, the paper begins by detailing the changing nature of power quality in distribution networks followed by a description of the main types of power quality issues and an overview of the key standards governing network limits. The focus then shifts to harmonic reduction procedures and methodologies. A review of harmonic reduction methods based around the design of rotating electrical generators is developed, followed by a review of modern methods applied to new generation systems, such as renewable sources.

Keywords- Harmonics, Total Harmonic Distortion (THD), DC Power, Distribution System, Passive Filter, Harmonic Reduction

Literature Survey

Sanjib Kumar Nandi et al. (2015) Usages of DC power instead of AC power on the secondary distribution system creates a lot of harmonics. Our goal is to eliminate the harmonics onto the system and due to the limited specification of filter it has not been possible to reduce all the harmonics in the secondary distribution system. But we must be more focused to achieve this goal, because large shares of household loads are turning into DC in recent years. If this trend continues, the impact of harmonics on customer end will reach a level which might be detrimental and redundant to both loads and grid. The main objective of this research is to explain the effects of harmonics on the low voltage direct current (LVDC) distribution system and measure the harmonic content present in the network and proposed a recovery method by inserting filter. Due to additional non-linear loads on the LVDC distribution system, a sufficient amount of harmonics will be created. To solve this issue, use of passive harmonic filter is recommended for the DC operated secondary distribution system.

Daniel Fallows et al. (2018) This paper provides a comprehensive literature review of techniques for harmonic related power quality improvement of electrical generation systems. An increasing interest in these aspects is due to the ever more stringent power quality requirements, deriving from new grid codes and compliancy standards, aimed at limiting waveform harmonic distortion at all points of the distribution network.

Geena Sharma and Kanchan Jaswal (2016) Active power filters are the emerging devices, which can diminish harmonic pollution effectively. Normally, the shunt APF is controlled such that it eliminates the load current harmonics and supplies load reactive power to achieve harmonic free source currents at unity power factor. However, these control objectives cannot be achieved simultaneously when the supply voltages are distorted and unbalanced (non-ideal).

Mrs. M. Sindhubala and Ms. Allan Mary George (2013) The principle of this paper is to know the effects of harmonics in a power system and to minimise the effects of the power system harmonics. This distortion will result in low power quality and improved disturbances in power system. So this harmonic technique is used to improve the power quality. The increase in power quality using a technique is explained in detail here.

Erwin Normanyo (2013) Three-phase four-wire distribution systems are very common and widely used in commercial and industrial installations and therefore power systems harmonics is an area that merits a great deal of attention.

Advancement in semiconductor devices has fuelled an increase in the use of non-linear loads which are the main causes of harmonic distortion in three-phase, four-wire distribution systems. Mitigation of harmonics in three-phase, four-wire electrical power distribution systems that supply balanced and unbalanced non-linear loads was therefore conducted. This paper proposes an approach to compensate for harmonics in a three-phase four-wire power distribution system. The mitigation principle is described, and some interesting filtering characteristics are discussed.

Jonathan K. Piel (2004) Power consumption of harmonic drawing loads is an increasing concern for cost conscious facility managers and engineersThe paper illustrated that up to 8% kW reduction could be realized by eliminating harmonic current at various points in a power distribution system, with the greatest benefits achieved with harmonic mitigation applied at the point of use. The research and results were reached through mathematical modeling of system losses and performance. This paper presents the design and simulation hybrid active filter based on voltage detection consisting of seventh-tuned LC passive power filter and a 3ϕ active power filter connected in series to mitigate the harmonic propagation under the worst-case situation that is under no load. The filter is connected in parallel to the system. Simulation is carried out for a 415V, 50Hz system in MATLAB. The THD is reduced from 19% without filter to 1.5% with the addition of hybrid filter.

Dinari Kiran Kumar et al. (2017) The improvement in technologies over the recent years has led to the increase of power electronic loads in distribution feeders. Thus, leading to increased usage of capacitors for correcting the power factor in distribution systems. This causes harmonic propagation because of resonance amongst line inductances and capacitors used for correcting power factor. This situation is worst during no-load conditions. In real power distribution systems, this situation occurs at night times. To mitigate these harmonics active filters had been proposed and tested [1]-[2]. These active filters act like damping resistor to harmonic frequencies. It's not economically feasible to install filters at the neighbourhood of each harmonic producing load, to achieve harmonic mitigation throughout the feeder filters must be installed at the end terminal of the distribution feeder [3]. The cost of installing active filters should be taken care by the electricity supply company. Practically size of the active filters is too large for installation on the electric poles. Problems of cost and size can be overcome with the help of a new alternative of shunt hybrid active filter is proposed [4]. The shunt hybrid active power filter is the combination of a tuned passive power filter and an active power filter connected in series with each other. The voltage detection based hybrid power filter acts like damping resistor to the frequencies of the harmonics. Simulation results is obtained for a hybrid active power filter connected to a 415V, 50Hz feeder simulator. The complete control of the filter is digital.

Md. Siddikur Rahman (2017) Among all the existing network technologies, LVDC system is one of the emanating technology renovations for Smart Grid application to the distribution of electricity and a highly interesting challenge [1]. The salient purposes beyond this development of the LVDC network is to enhance the power quality and furnish security experienced by the end users of the electricity for ameliorating the distribution economy [1]. This pledge flexible and robust coupling point for small scale generation and evolve infrastructure for interactive and intelligent distribution network [1, 2]. The distribution transformer is one of the key parts of LVDC system [3]. The nonlinear nature of the load has generated harmonic currents which may cause problems in the power system and overheating transformers. Nonlinear loads have generated harmonic currents which are flown from the load towards the power source, following the least impedance paths [4]. Modern electrical system consists of a vast amount of nonlinear loads which causes disturbances in DC current. Commercial buildings often have a large amount of nonlinear electronic loads such as lighting, computers, monitors and adjustable-speed drives for air conditioning. Due to this huge presence of nonlinear loads, electromagnetic-compatibility and power quality problems may occur [5]. For which power system suffers from unfavorable consequences and may damage electrical equipment's. IEEE Standard 519-1992 specifies limits for each harmonic up to the 35th and limits the total harmonic distortion (THD) to 5% [6]. EN 50160 limits the THD to 8% and the unbalance to 2% [7]. This problem can require special consideration to serve non-linear loads with a reduce amount of harmonic distortion. Using various techniques power distribution system's Harmonic distortion might be restrained [2]. Previously, researches have been conducted on load behavior and harmonic contribution in various sectors of the power system. For instance, The LVDC power distribution network concept is presented [8]. Harmonic analysis and DC operated electrical system with distributed resources for recovery from the effects of harmonics and closely relevant criteria have been proposed in [9, 10, 11 and 12]. The LVDC distribution system concept has been developed in [13]. Passive filter installation for reducing harmonic in single phase motor, varying load has been introduced.

Allan Mary George et al. (2014) The term harmonics referred to Power quality in ideal world would mean how pure the voltage is, how pure the current waveform is in its sinusoidal form. Power quality is very important to commercial and industrial power system designs.A perfect sinusoidal waveform must be without any kind of distortion. If there is any distortion in terms of current or voltage it will be called as harmonic distortion. This distortion can be due to many reasons. Now - a- days, engineers try very hard to derive some methods to reduce the harmonic distortion. Because of the simple and conservative designs of power systems, harmonic distortion was less before. but now the harmonic distortion has increased very well due to the complex designs in the industry. This project helps us to understand the effects of harmonics in power system and explains the way to reduce it. From this project we can also be able to know the important problems related with power quality and the disturbances to the power system. This project includes the techniques to reduce the harmonics and to improve the power quality. It also includes simulation for the same. This project also explains different types of inverters that are used in the Power System. During the transformation from DC to AC, harmonics affect the power quality a lot. How harmonic reduction will improve the power quality will be explained in detail as shown.

Daniel J. Carnovale In the near future, predictions concerning the "digital economy" indicate that more than 50% of all power consumed in the North America will be through power electronic devices including switch-mode power supplies, variable frequency drives, and other power electronic equipment. Harmonics drawn by these loads have significantly changed the power system requirements to protect these loads and to protect the system from these loads. The function of the distribution system is to deliver fundamental current to the terminals of the load. Generally, fundamental current is the only component of current which performs useful work. In contrast, harmonic current is simply the "by-product" of the way non-linear loads draw current and are not necessary to perform useful work.

A.Kumar et al. (2017) The improvement in technologies over the recent years has led to the increase of power electronic loads in distribution feeders. Thus, leading to increased usage of capacitors for correcting the power factor in distribution systems. This causes harmonic propagation because of resonance amongst line inductances and capacitors used for correcting power factor. This situation is worst during no-load conditions. In real power distribution systems, this situation occurs at night times. To mitigate these harmonics active filters had been proposed and tested [1]-[2]. These active filters act like damping resistor to harmonic frequencies. It's not economically feasible to install filters at the neighbourhood of each harmonic producing load, to achieve harmonic mitigation throughout the feeder filters must be installed at the end terminal of the distribution feeder [3]. The cost of installing active filters should be taken care by the electricity supply company. Practically size of the active filters is too large for installation on the electric poles. Problems of cost and size can be overcome with the help of a new alternative of shunt hybrid active filter is proposed [4]. The shunt hybrid active power filter is the combination of a tuned passive power filter and an active power filter connected in series with each other. The voltage detection based hybrid power filter acts like damping resistor to the frequencies of the harmonics. Simulation result is obtained for a hybrid active power filter connected to a 415V, 50Hz feeder simulator. The complete control of the filter is digital

Conclusion

In electrical power system, harmonic current pollution is a one of the most major power quality problem that need to be solve to get the good or excellent power supply. This make power quality is really important in the distribution system. In the other side, there also several phenomena that can cause an interruption or disturbance due to the power supply which is overvoltage , voltage sags, voltage surges and harmonic. Current harmonic distortion can be identifying due to the non-linear relationship between the voltage harmonic and percentage load of the common harmonic producing device like electrical equipment in the office building [1] . As already know that harmonic distortion is a pollution form of the electric network which is being problematic when the sum of harmonic current is biggest compare to the boundary-values. In office building, the electrical circuits that were designed for a relative plug load may be overload by electronic equipment. This because there are growing and implementation in electronic equipment that widely used nowadays. Electronic equipment like fax machine, printers, computers and air conditioner actually can provide a significant increase in office productivity. Besides that, this equipment will turn on a high percentage of overall demand factors. In the same time, it's also allowed maximum load as a per cent of connected load. Building wiring also can associate the most losses of the harmonic.

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