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Performance Analysis of Shunt Compensation in Power System

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ABSTRACT

The term electric force quality extensively alludes to keeping up an almost sinusoidal force circulation transport voltage at evaluated greatness and recurrence. What's more, the energy provided to a purchaser must be continuous from dependability perspective. Despite the fact that power quality is basically a dissemination framework issue, power transmission framework may likewise have sway on nature of intensity. Electrical frameworks are dependent upon a wide assortment of intensity quality issues which can intrude on creation measures, influence delicate gear, and cause vacation, scrap, and limit misfortunes. Transient voltage changes can grievously affect creation broadened blackouts have a more prominent effect. Many force quality issues are effortlessly recognized once a decent portrayal of the issues is gotten. Shockingly, the pressures brought about by power issues regularly bring about unclear or excessively emotional portrayals of the issue. At the point when power issues occur, one must attempt to take note of the specific season of the event, its impact on electrical hardware, and any as of late introduced gear that might have acquainted issues with the framework.

KEYWORDS: *Voltage, Magnitude, Power Quality*

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1. INTRODUCTION

Over the past few years, the enormous increase in the use of non-linear loads arises many power quality issues like high current harmonics, voltage distortion and low power factor etc. on electrical grid. Hence the proliferation of non-linear load in system generates harmonic currents injecting into the AC power lines. This distorted supply voltage and current cause's malfunction of some protection devices, burning of transformers and motors, overheating of cables. Hence it is most important to install compensating devices for the compensation of harmonic currents and voltages produced due to nonlinear load. Traditionally, passive power filters have been used as a compensating device, to compensate distortion generated by constant non-linear loads. These filters [2] are designed to provide a low impedance path for harmonics and maintaining good power quality with a simplest design and low cost. However, passive filters have some demerits like mistuning, resonance, dependence on the conditions of the power supply system and large values of passive component that leading to bulky implementations.

For high-quality power requirements, numerous topologies of active filters i.e. APF connected in series or in parallel (series active filters and shunt active filters) to the nonlinear loads with the aim of improving voltage or current distortion. These filters are the most widely used solution, as they efficiently eliminate current distortion and the reactive power produced by non-linear loads. But they are generally expensive and have high operating losses.

2. Scope of Work

Power electronics-based devices/equipment are a major key component of today's modern power processing, at the transmission as well as the distribution level because of the numerous advantages offered by them. These devices, equipment, nonlinear load including saturated transformers, arc furnaces and semiconductor switches and so on, draw non-sinusoidal currents from the utility. Therefore a typical power distribution system has to deal with harmonics and reactive power support.

The purpose of this chapter is to review the main researches conducted on voltage regulation techniques at the distribution level as well as the Custom Power Device technologies. In the studies of voltage regulation, the distribution level is considered both the medium voltage (MV) and low voltage (LV). The scope of this thesis is the LV side, hence, there searches tackled in this review are only those related to LV side of the power distribution network.

3. Literature Review

The voltage control problems can be defined as the assurance of maintaining electric power quality for all consumers. Disturbances like over-voltage, under-voltage, voltage unbalance, and voltage harmonic distortion affect the power quality which imposes to control the voltage to avoid such problems. The two approaches of voltage control are the off-line control that depends on a dispatch schedule ahead of time as a forecast of the voltage changes; and the on-line (automatic) that depends on real-time measurements of the voltage [1].

Moreover, the active network management of a power system may be categorized into coordinated control, semi-coordinated or decentralized control strategies. As mentioned in, centralized or coordinated control strategy provides voltage control from the substation towards the rest of the network. On the other hand, the semi-coordinated and decentralized control strategies must be able to control each unit locally in an active manner while coordinating it with a limited number of other network devices [2].

The voltage drop on a line between the source bus-bar and the load is calculated by Automatic Voltage Control (AVC) relay using the input current and the impedance value of the line. The relay adjusts the control parameter to increase or compensate the source bus-bar voltage by an amount equal to the calculated voltage drop. The impedance of a line might not be accurate since there might be several branches extending from one feeder like in tree network arrangement. In addition, the AVC relay can have one feeder resistance (R) and reactance (X) setting although most substations have multiple feeders. In order to resolve these shortcomings, the R and X settings on the LDC is based on a hypothetical composite feeder model that has to cater for the worst combination of demands on each of the feeders [3].

The authors present an overview of the existing OLTC control schemes used to control the voltage at distribution network. The authors summarize the operations and coordination of the OLTCs in the full electric network from the transmission up to the distribution side [4].

The authors in proposed an algorithm to control the voltage of each node by determining the sending voltage of the substation in a certain time section, the tap location of the step-voltage regulator, the on-off states of the shunt capacitor, and the capacity of the static VAR compensator [5].

4. Problem Statement

The development in the power industries increases the number of both linear and nonlinear loads in every system. In the non-linear loads conditions, many solid states switching converters draw reactive power and current harmonics from the AC grid. These non-linear loads generate harmonics, which produces disturbance and directly impact every equipment, power system and services. The shunt active power filter (SAPF)topologies for harmonic compensation use numerous high-power rating components and are therefore disadvantageous. Hybrid topologies combining low-power rating APF with passive filters (PFs) are used to reduce the power devices (IGBTs) rating of voltage source inverter (VSI). Hybrid APF (HAPF) topologies for high-power rating system applications use a transformer with large numbers of passive components. When connected to the electrical grid, the increased number of semiconductor switch components produces higher switch losses, which contributes to harmonics in the output voltage waveform, degrades the system efficiency, and causes the overall system performance to deteriorate.

Also as a limitation the series LC passive filter produces an unavoidable fundamental leading current flow in the system. Furthermore, the reactive power compensation capability of conventional hybrid APF is limited due to series LC passive filters (fixed value), which is the main disadvantage of the hybrid APF system.

5. Objective

The main objective of this thesis is to develop a three phase four wire based Shunt Active Power Line Conditioner (SAPLC) to compensate the neutral current produce by the unbalanced system as well as the improve the power quality of the distribution system in power grid. For so the following action can takes place:

- To describe the Power quality issues in the modern power grid and study the negative influence of the Power Quality problem. Also study the problem resolving technique used by the custom power device.
- To study based on the literature of the power quality issue and the resolving technique in the modern power grid.
- To compensate the neutral current due to unbalanced System in the Distribution Grid.

- To develop the proposed Shunt Active Power Line Conditioner (SAPLC) to resolve the issue created by the unbalanced load in the distribution system of the power grid.
- To simulate the proposed methodology in MATLAB software to check the performance of the proposed system for distribution system.

6. Methodology

Power quality 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 of Power quality is the properties of voltages in the system to be design that the user of electric power without interference or interruption can utilize the voltage from the distribution system successfully . The next explanation is "Power quality is the combination of voltage quality and current quality, therefore the ideal power quality is concerned with deviations of voltage and current .On the other hand the way of power quality problems are described. "Basically the quality of the power supply consists at two elements the supply reliability and the voltage quality. The concept power quality involves two parties it can be concluded that based on the previous descriptions. The power quality can then be regarded as a measure of purity of the energy which is transferred from the supplier to the user.

If the ideal Current quality is concerned with deviations of the current. The ideal current properties are a single-frequency and sine wave and it has constant frequency and magnitude. An any additional requirement is the sine wave have in phase with the supply voltage. Then the voltage quality has consumer takes from the utility to do with the utility delivers to the consumer current quality is concerned. The Voltage and current are strongly related it is hard for the other to be ideal if either voltage or current deviates from the ideal . The voltage quality will concerned with deviations of the voltage from the idea .The ideal voltage to be a single frequency sine wave of constant frequency and constant magnitude.

The term quality of voltage can be interpreted as the quality of the product delivered by the utility to the customers.The Power quality problem is defined as any power problem it has manifested in voltage current or frequency deviations those result in failure or miss-operation of customer equipment's. Only control the quality of the voltage through power supply system . It has no control over of currents that particular loads might fall down . That is the standards of the power quality are within certain limits are devoted to maintaining the rated voltage . Any significant deviation of power quality problem in the waveform magnitude frequency or purity is a potential. Of course, there is always any practical power system relationship between voltages and current is a close. Although the generators may provide a near-perfect sine-wave of voltage ,the current passing through the impedance of the system can cause a different types of voltage disturbances .The Power quality is a any electrical power system often considered as a combination of voltage and current quality. In most of the cases, the network operator is responsible for the considered that voltage quality at the point of connection often influences of the current quality at the point of connection at the customers load.

7. Result and Discussion

The whole work is simulated in MATLAB software. Table 1 shows the simulation parameter used in this work. The whole simulation is run for 2 sec.

Table 1: SIMULINK Parameter Used in Proposed Work

System Parameter	Value
Source Voltage (V_{rms})	220 V
System frequency	50Hz
Line Parameter	Ls=0.1 mH, R_s= 0.1Ω
Passive inductance	L= 0.4mH
Coupling Inductor	L_f= 2mH
DC Side Capacitor	11µF
k_p	0.1
K_i	1
Non-Linear Load	L=3mH, R=30Ω
Unbalanced Load	R_a=50Ω, L=1mH R_b=50Ω, C=1µF R_c=10Ω

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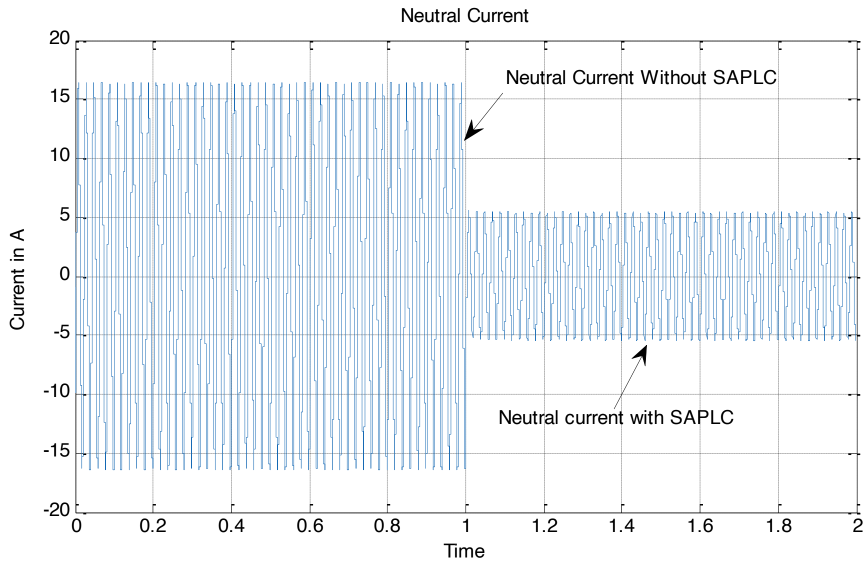

Figure 2: Neutral Current Compensation with & without SAPLC

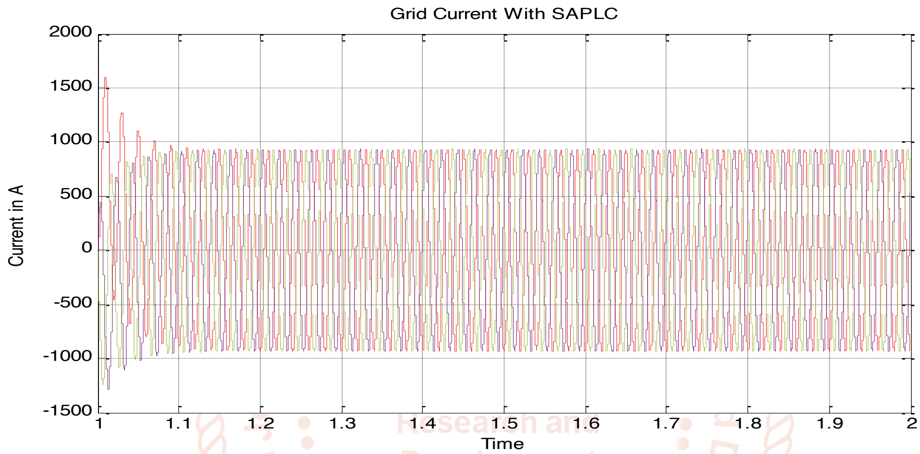

FIGURE 3: GRID CURRENT WITH PROPOSED SAPLC

The current get increases when the proposed SAPLC is applied to the unbalanced system.

Figure 3 and 4 shows the FFT analysis of the grid side current of the proposed system with and without proposed SAPLC.

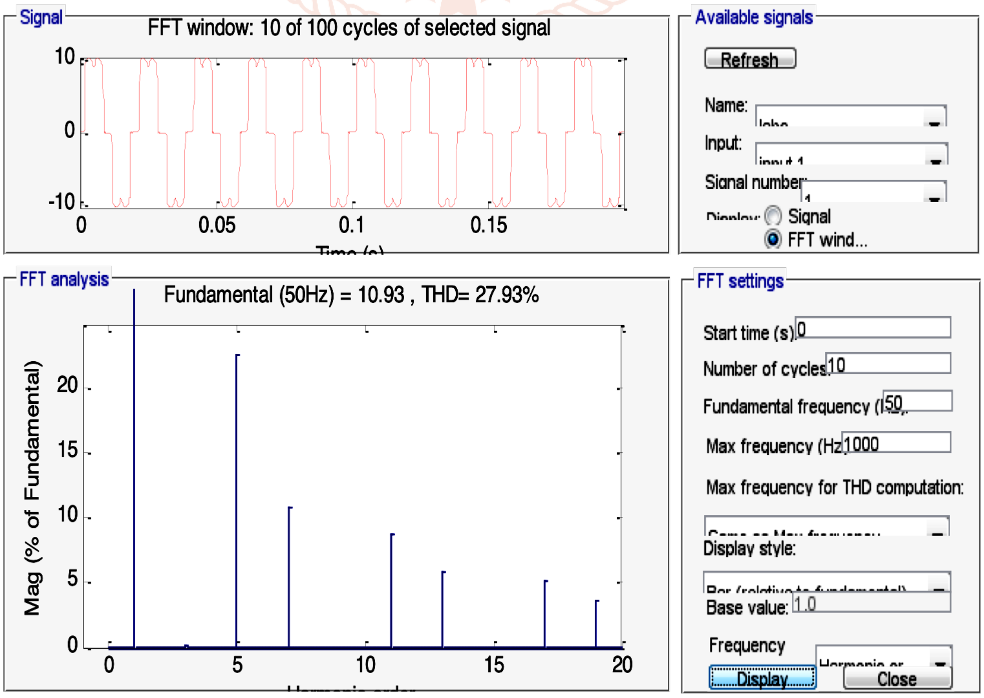

Figure 3: FFT Analysis of the Grid Side Current without SAPLC

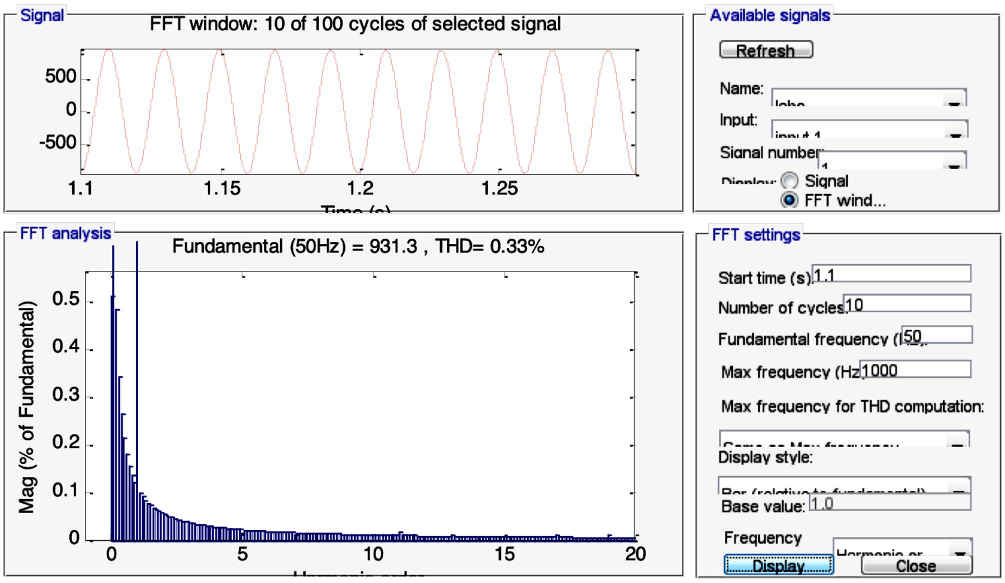

Figure 4: FFT analysis of Grid Side Current with SAPLC

Here from the figure 3 and 4 it is clearly seen that the THD of the system get improved from 27.93% to 0.33% with the application of proposed SAPLC.

7. Conclusion

A three phase four wire system based distribution system is always connected with different loads in the power system. Here in each phase is connected with the identical customer with varying load. Due to regular use of non-linear load power quality issue generate in the feeder. The unbalance in the system produces neutral current in the feeder which is unsafe for the distribution system. It causes several issues in the distribution system.

On the basis of this a new type of three phase four wire shunt active power line conditioner circuit is developed in this proposed work. For so firstly reviewed different literatures which are concentrated on the distribution system for improving voltage regulation in chapter 2. Further in chapter 3 discuss the power quality and control strategy of the distribution system in chapter 3. In this chapter also discuss the custom power device which is used regularly now a day for improving power quality issue. The concept of the instantaneous power theory is developed in chapter 4 which is used for proposed work.

The whole work is simulated in MATLAB software where the performance of the proposed system is checked with different type of load combinations. Here in the result it is found that the neutral current generated due to unbalanced system is compensated with the help of proposed work. Also found that the grid side current THD is reduces from 27.93% to 0.33 %.

This proposed work is based on the neutral current compensation technique. Here in thesis shunt active power line conditioner system is developed for reducing the neutral current presented by the unbalanced system. In future there are many aspect where the researchers can do work. Some of the future scope of this proposed work is as:

- The application of the proposed work is implemented in the hardware for small size of power distribution network.
- The realization of the other active power devices like DVR and APF for minimizing of power dissipation work can be consider in the future.
- Implementation of FPGA based custom power controller in the future for more precise the performance of the system.

Here in the proposed work uses two level VSI topology, in future multilevel inverter based topology is used for harmonic elimination technique.

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