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Improvement of Power Quality using Shunt Active Power Filter

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Abstract

This paper presents the enhancement of power quality for a microgrid system at distribution level using Shunt active power filter. The main objective of this paper is to identify a suitable pulse generation technique for obtaining a better compensation capability of shunt active power filter. The compensation capability of the device is mainly depends on the regulation of DC link capacitor voltage. Conventionally fixed hysteresis current control technique has been used. To raise the performance of shunt active power filter, an adaptive hysteresis current control technique has been proposed here. The performance of proposed technique has been verified for different operating condition in the platform of MA TLAB/SIMULINK model.

Keywords- Microgrid, Power quality (PQ), Shunt active power Filter, Adaptive hysteresis current control technique, Total harmonic distortion (THD).

I. INTRODUCTION

There are generally three types of APFs, they are series APF, shunt APF and UPQC (Unified Power Quality Conditioner). Series APF is gives compensation for voltage related problems like voltage sag, swell, flicker and unbalances. Shunt APF is a device which is used to compensate the current related problems like harmonics, inter harmonics and reactive power consumption. UPQC is the combination of series and shunt APF. So that it will provide both voltage and current related compensation [10], [12]. This paper deals with the application of shunt APF to the distribution system to mitigate the current related issues and provide a satisfaction to the customer by delivering good electrical power. The operation of shunt APF can be identified by using the control technique [2]. There are different control strategies provided by different authors. In this paper Unit Vector Template Generation is described. Among the different pulse generation techniques, here Adaptive hysteresis current control technique is chosen because of its simplicity and easy to implementation. In section 2, the concept of microgrid has been described, shunt APF was discussed in section 3, section 4 comprises of control technique for shunt APF, section 5 includes adaptive HCC technique, and mathematical formulation was described in section 6. The section 7 holds the results obtained from MA TLAB/SIMULINK model and its discussions. The final section incorporates conclusion part.

II Problem Definition

In order to facilitate these objectives and to reduce greenhouse gas (GHG) emission, research on various configurations of microgrid (μG) system is gaining importance, particularly with high penetration of renewable energy sources. Depending on the resource Availability, geographical locations, load demand, and existing electrical transmission and distribution system, μG can be either connected to the grid or can work in an autonomous mode. Storage can also be a part of the μG architecture (2).

The present power system scenario mainly focused on the issue of power quality problems. The major research topic in the power distribution system is to improve the quality of power [1]-[3]. The primary cause for poor power quality is the arrival of power electronics based devices and non-linear loads in industries as well as commercial applications. The ideal power system has balanced, pure sinusoidal phase supply, the loads operating with unity power factor and zero harmonics. But practically this is not possible because the system comprises of linear and non-linear loads. Due to these complex loads there will be a change in the system parameters such as voltage, current and frequency together they are termed as 'Power quality issues'. The poor power quality results malfunction of devices and equipment, voltage and current harmonics and unbalances, low power factor and reactive power consumption. Among these harmonics is the primary index for poor power quality. Hence it is necessary to mitigate these power quality issues and maintains the % THD within certain limits as per IEEE standards. Due to the development in the field of power electronics and the digitalized control technology the entry of custom power devices is encouraged. A most widely used custom power device is called active power filters (APF).

III LITERATURE BACKGROUND

(Enjeti et al., 1992), entitled "Analysis and design of an active power filter to cancel harmonic currents in low voltage electric power distribution systems", presents active power filter design considerations used for improving current quality in low voltage electric power distribution systems. Among various types of filters, shunt active filter is used for current harmonics removal and improves the power quality in electric power distribution system.

(Adil M. Al, -Zamil.,**2001),** entitled "The unified power quality conditioners: the integration of series active and shunt-active filters", In this paper the main purpose of a UPQC is to compensate for voltage flicker/imbalance, reactive power, negative sequence current, and harmonics. In other words, the UPQC has the capability of improving power quality at the point of installation on power distribution systems or industrial power systems. This paper discusses the control strategy of the UPQC, with a focus on the flow of instantaneous active and reactive powers inside the UPQC.

(Singh, Bhim Al-Haddad et al., 1999), entitled "Harmonic elimination, reactive power compensation and load balancing in three-phase, four-wire electric distribution systems supplying non-linear loads" In this paper, a new control scheme of a three-phase active power filter (APF) is proposed to eliminate harmonics, to compensate reactive power and neutral currents and to remedy system unbalance, in a three-phase four-wire electric power distribution system, with unbalanced non-linear loads. The APF is realized using three single phase IGBT based PWM-VSI bridges with a common dc bus capacitor.

(Bhimsingh et al., 1999), entitled " A review of active filters for power quality improvements", presents in this paper presents a comprehensive review of active filter (AF) 21configurations, control strategies, selection of components, other related economic and technical considerations, and their selection for specific applications. It is aimed at providing a broad perspective on the status of AF technology to researchers and application engineers dealing with power quality issues.

IV POWER SYSTEMS AND POLLUTION

Electric systems and grids are complex dynamic systems. These systems suffer usually from unexpected or sudden changes of the currents and voltages. These changes are due mainly to the different types of linear and non-linear loads to which they are connected. In addition, to different types of accidents which can intervener into the grid [31]. With the increasing use of power semiconductors in the most of industrial and domestic procedures, the electric grids are polluted with different harmonic currents and voltages. These harmonics affect the normal function of the most of the grid connected devices; in addition to considerable economic losses. Many classic and modern solutions have been proposed in the literary for the harmonic problems. In this chapter, the harmonic problem as one of the most common power quality problems will be presented. The different modern and traditional solutions will then be discussed.

Power Systems Distortion and Problems

In power systems, different voltage and current problems can be faced. The main voltage problems can be summarized in short duration variations, voltage interruption, frequency variation, voltage dips, and harmonics. Harmonics represent the main problem of currents of power systems.

Voltage Variation for Short Duration

The short duration voltage variation is the result of the problems in the function of some systems or the start of many electric loads at the same time. The defaults can increase or decrease the amplitude of the voltage or even cancel it during a short period of time [31]. The increase of voltage is a variation between 10-90% of the nominal voltage. It can hold from half of a period to 1 minute according to the IEEE 1159-1995. According to the same reference, the increase in voltage is defined when the amplitude of the voltage is about 110-180% of its nominal value.

Voltage Interruption

The cutoff of the voltage happens when the load voltage decreases until less than 10% of its nominal value for a short period of time less than 1 minute. The voltage interruption can be the effect of defaults in the electrical system, defaults in the connected equipment's, or bad control systems. The main characteristic of the voltage interruption is the period over which it happens.

Frequency Variations

In the normal conditions the frequency of the distribution grid must be within the interval 50±1 Hz. The variations of the frequency of the grid can appears to the clients who are using auxiliary electric source (solar system, thermal station…etc). These variations are rare and happen in the case of exceptional conditions like the defaults in the turbines.

Unbalance in Three Phase Systems

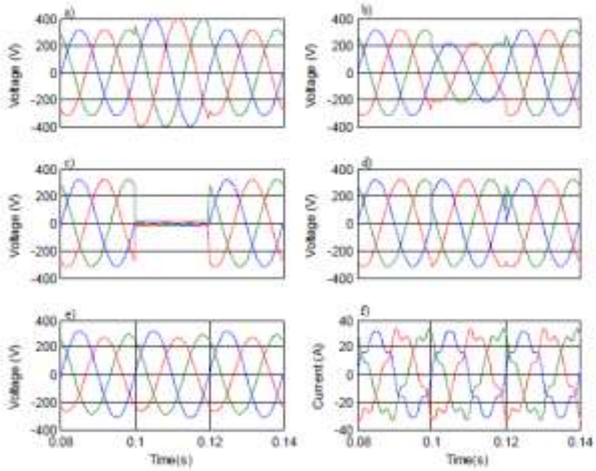
The three phase system is unbalanced when the currents and voltages are not identical in amplitude; or when the phase angle between each two phases is not 120°. In the ideal conditions, the three phase system is balanced with identical loads. In reality, the loads are not identical, in addition to the problems of the distribution grids which can interfere.

Voltage Dips (Sags)

The voltage dips are periodic perturbations. They appear as a natural effect of the switching of the transistors. They are due also to the start of big loads like motors. Lifts, lights, heaters…etc. this phenomena causes bad functioning of the protection equipment's.

Harmonics

Power systems are designed to operate at frequencies of 50 or 60 Hz. However, certain types of loads produces currents and voltages with frequencies that are integer multiples of the 50 or 60 Hz fundamental frequency. These frequencies components are a form of



Most encountered power system problems. a) Voltage swells. b) Voltage sags. c) Voltage interruption. d) Frequency variation. e) Voltage unbalance. f) Harmonics.

Harmonics are familiar to the musicians as the overtones from an instrument. They are the integer multiples of the instrument's fundamental or natural frequency that are produced by a series of standing waves of higher and higher order. Electrical pollution known as harmonic distortion. There are two types of harmonics that can be encountered in a power system.

- Synchronous harmonics.
- Asynchronous harmonics.

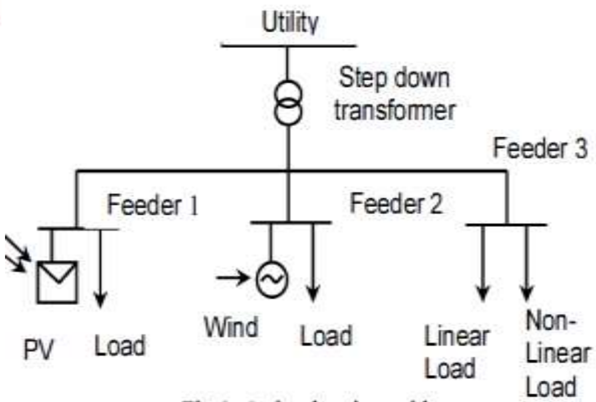
Synchronous harmonics are sinusoids with frequencies which are multiples of the fundamental frequency. The multiplication factor is often referred to as the harmonic number. The synchronous harmonics can be subdivided into two categories.

- Sub-harmonics: when the harmonic frequency is less than the fundamental frequency.
- Super harmonics: when the harmonic frequency is more than the fundamental frequency.

V Proposed methodology

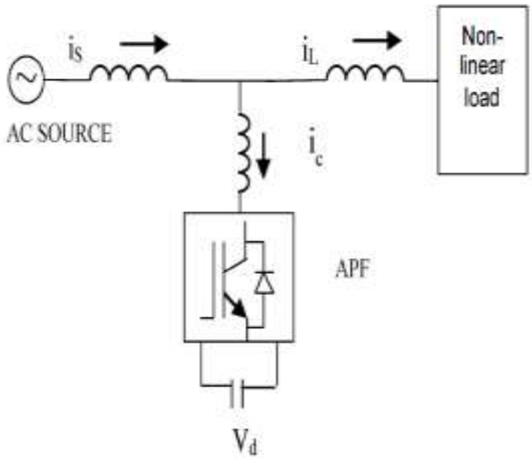
MICROGRID

A simple microgrid system consists of linear and non-linear loads is shown in fig. 1 In earlier days the generating units are in one place and the generated power is transmitted to the load through a long transmission and distribution system, hence there will be a power demand and also the loss is high due to long transmission line which leads the efficiency of the system gets reduced. In order to overcome the drawbacks of conventional electrical grid system the concept of microgrid grid system was proposed [9]. Here the power demand is meet out by the integration of small renewable energy sources and also the losses are minimized which causes the efficiency of overall system gets improved. There will not be any power shortages so that the reliability of system is improved [15]. Here the renewable sources PV and wind are considered as an ideal source. In the next section the power quality issues in microgrid system was proposed.



VI SHUNT ACTIVE POWER FILTER

The diagram for shunt active power filter is shown in figure2. The shunt active power filter is a device which is connected in parallel at the Point of Common Coupling (PCC). The center point where the source and the load are meeting is called as PCC.



Generally the active power filter consists of inverter topology in it which may be voltage source inverter (VSI) or current source inverter (CSI). Most of them prefer VSI based shunt active power filter because CSI holds some of the drawbacks [5], [6]. At the output terminal of the VSI a dc link capacitor is connected which acts as an energy storage element and is used to maintain a constant DC voltage with small ripple in steady state. The dc link voltage of the capacitor has to be maintained as constant in order to achieve a better compensation. This is achieved with the help of closed loop operation that is PI controller. The shunt active power filter provides compensation for current related problems like harmonics, low power factor and reactive power consumption. This is accomplished by applying a suitable control technique for VSI [2], [8]. The next section holds the control technique for shunt APF.

Active Power Filters

The function of the active power filters (APF) is to generate either harmonic currents or voltages in a manner such that the grid current or voltage waves conserve the sinusoidal form. The APFs can be connected to the grid in series (Series APF), shunt (SAPF) to compensate voltage harmonics or current harmonics respectively. Or can be associated with passive filters to construct the hybrid filters (HAPF).

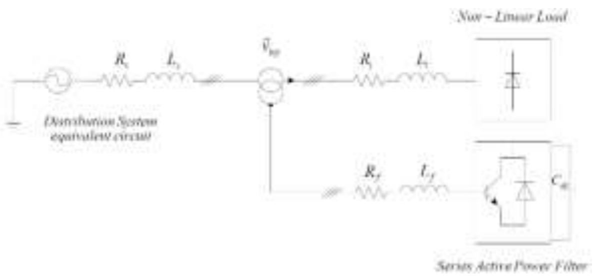
Active filters are relatively new types of devices for eliminating harmonics. This kind of filter is based on power electronic devices and is much more expensive than passive filters. They have the distinct advantage that they do not resonate with the power system and they work independently with respect to the system impedance characteristics. They are used in difficult circumstances where passive filters don’t operate successfully because of resonance problems and they don’t have any interference with other elements installed anywhere in the power system [38].

The active filters present many other advantages over the traditional methods for harmonic compensation such as [33]:

- Adaptation with the variation of the loads.
- Possibility of selective harmonics compensation.
- Limitations in the compensation power.
- Possibility of reactive power compensation.

Series Active Power Filter (series APF)

The aim of the series APF is to locally modify the impedance of the grid. It is considered as harmonic voltage source which cancel the voltage perturbations which come from the grid or these created by the circulation of the harmonic currents into the grid impedance. However, series APFs can’t compensate the harmonic currents produced by the loads.



CONCLUSION

An extensive review of AF's has been presented to provide a clear perspective on various aspects of the AF to the researchers and engineers working in this field. The substantial increase in the use of solid-state power control results in harmonic pollution above the tolerable limits. Utilities are finding it difficult to maintain the power quality at the consumer end, and consumers are paying the penalties indirectly in the form of increased plant downtimes, etc. A large number of AF configurations are available to compensate harmonic current, reactive power, neutral current, unbalance current, and harmonics. The consumer can select the AF with the required features. It is hoped that this survey on AF's will be a useful reference to the users and manufacturers.

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