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A review on Aspects of Power Quality Improvement Using Active Power Filter

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Abstract: Selecting or developing electronics employing pulse-width modulation (PWM) to control brushless dc motors may be difficult for motion system designers. To minimise unanticipated performance concerns, it is helpful to bear in mind several fundamental physical phenomena. Concern about power quality at the distribution and consumer levels, as well as the requirement to regulate reactive power and maintain voltage stability at the transmission level, have sparked a great deal of research and development into active filters. The study of active filters has expanded in recent years. In this study, we will examine the existing research on active filters. Time domain and frequency domain analysis are used to categorise the various active power and reference current production techniques.

Keywords: Active power filters (APF), composite load, harmonic compensation, linear and nonlinear load, reactive power.

I.INTRODUCTION

Electric power quality can be described as the degree to which the voltage, frequency and waveform of a power supply system match to established specifications. A good power quality can be stated as a steady supply voltage that remains within the prescribed range, a steady ac frequency that is close to the rated value and smooth voltage curve waveform preferably a sinusoidal wave. In other words it can also be stated as the compatibility between output of an electric outlet and the plugged in load. In absence of proper power, an electrical device tends to malfunction, prematurely fail or not at all operate. While "power quality" is a suitable term but actually it is the quality of the voltage rather than power or electric current that is actually described by it.

The power quality may be expressed as a set of values of parameters, such as:

- Continuity of service irrespective of voltage sag/swell
- Voltage magnitude variations
- Transient currents and voltages
- Harmonics in the waveforms

A. POWER FILTERS

In the majority of commercial, industrial and utility networks, power quality problems are pervasive. Natural phenomena, like lightning, are the most common source of issues with energy efficiency. Switching phenomena, like, when capacitors are switched, usually lead significantly to disruptions in power quality. The presence of high power non-linear loads also contributes to the generation of harmonic components of current and voltage. Voltage sags are the most important and critical power quality issues among the numerous voltage disruptions that can be produced, due to the high economic losses that can be generated. Voltage sags or Short-term voltage drops can cause production interruptions in electrical drives or more sensitive devices. Therefore power quality is an important element to be considered for maintaining higher efficiency of the system.

Power electronic energy conversion equipment is steadily integrated into all stages of the power grid with better focus to high performance and energy conservation. Due to nonlinear operation, the snag of such equipment is the generation of non sinusoidal currents in the power delivery network.

Harmonic currents can distort line voltages and cause many unintentional consequences, including overheating of devices, device breakdown, communication system interruption, etc. Here comes the role of an active filter for cancellation of harmonic line current distortion in response to these issues. These problems can be also reduced using passive filters, which usually consist of resistors, inductors, and capacitors, and also they don't depend on one form of external power source.

The inductors obstruct high frequency signals and execute low frequency signals. The condensers do the same. The application areas of the passive filters are limited in the present scenario even though they may be used to decrease the amount of harmonic currents, as well as to increase strength. The primitive electronic filter tends to be passive analog filters, since they are normally very basic with only resistors, capacitors and inductors.

Following are few of the filters:

• Band pass filters are the circuits which cause signals of two different frequencies to pass through and not let other frequencies through. This filter enables us to have an external power source and active parts, such as transistors and are termed as active band pass filters. Whereas, passive band pass filters doesn't use an external source of electricity.

• Signal filters delete any type of unnecessary signal or part in signal. In order to enhance efficiency and remove background noise, some of the frequencies are removed and some are retained.

• Sinusoidal filter is common in engines and can provide a variety of different benefits when properly implemented. By decreasing the harmonics and reducing current, it could help to maximize the life of the engine. Also there will be less heating, increased efficiency of the engine. It also decreases the amount of noise and reduces spikes in voltage.

B. ACTIVE POWER FILTER

An active power filter also termed as a shunt active power filter, is usually attached parallel to load. In order to cancel the harmonics produced by the nonlinear load, it injects negative harmonic currents into the string. Fig.1 depicts the idea of the current cancellation of harmonics for enhancement of power efficiency.

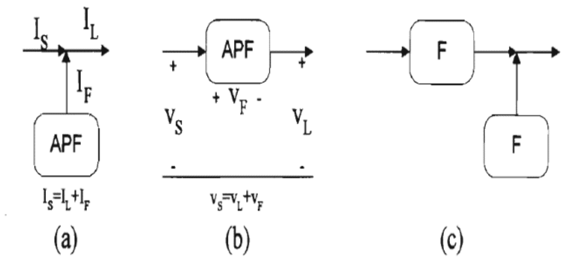

Fig 1: Active power filter (a) Shunt (b) Series (c) Hybrid filter

II.LITERATURE REVIEW

B. Singh, K. Al-Haddad and A. Chandra et al. [1] Active filtering of electric power has currently become an established technology for harmonic and reactive power compensation in two-wire, three-wire and four-wire AC power networks carrying nonlinear loads. Here a comprehensive review of active filter configurations, control strategies, selection of components, other related economic and technical considerations, and their selection for specific applications is been discussed. It also provides a wide outlook on the status of active filtering technology for researchers and application engineers dealing with power quality issues.

T. C. Green and J. H. Marks et al. [2] there are many proposed variants of the active power filter and these variations envelop both the circuit topology and the control system used. Some of the control variants reveal different control objectives but there are still various variants within analogous ideas. The available control techniques are expressed and contrasted in a structured way to identify their performance strengths. Objectives are classified by the supply current components to be corrected and by the response required to distorted grid voltage. The various signal transformations are expressed in terms of their impact on the distortion identification problem. Time-domain, frequency-domain, instantaneous power and impedance synthesis methods along with additional control functions such as DC-bus voltage and current reference following are also discussed and found that a key difference between control methods is the way in which current distortion is treated in the presence of distorted grid voltage.

Zhaoyang Yan and Guiping Zhu et al. [3] Active Power Filter (APF) is an important power electronic device used to compensate the load harmonic current so as to improve power quality of the system. Stability of voltage across the capacitor in DC side of APF is one of the key factors that determine the compensation effect. Therefore voltage ripple must be controlled within allowed range. The theoretical expressions of voltage ripple across the capacitor in DC side of APF caused by kth order harmonic current is been deduced for three-phase and single phase APF respectively. The voltage ripple caused by multi-order harmonic currents is deduced by superposition theorem. Crucial factors leading to voltage ripple are analyzed based on the above theoretical deductions and is concluded that the ac components in the instantaneous power of AC side of APF are mostly responsible for the voltage ripple across the capacitor.

T. Thomas, K. Haddad, G. Joos and A. Jaafari et al. [4] showcase the feasibility of a three phase active filter based on a half-bridge topology. Also the design guidelines for the power circuit have been derived and applied to a 5 kVA IGBT laboratory prototype. In the single phase mode, the active filter can reduce the low frequency harmonic content in the AC line to below 1% excluding the harmonics due to switching action of the converter. In the three phase mode, line currents are corrected under balanced and unbalanced conditions. The neutral current is reduced significantly.

H.Kuo, S.Yeh and J.Hwang et al. [5] depicts a simple analytical model for the design and implementation of a three-phase active power filter controller. Voltage de couplers and pole-zero cancellation are used in current regulators so as to simplify the current control plant to a first-order delay type. This simplification is made by considering the delay times caused by the low pass filter of reference current calculation circuits, line inductors of an active power filter and the feedback circuit of a DC-link voltage. From the derived analytical model, the cutoff frequency of the low pass filter and controller parameters can be appropriately determined so as to increase the harmonic current compensating capability of an active power filter and accelerate the dynamic response of the DC-link voltage. The obtained results indicate that the proposed active power filter can largely improve the total harmonic distortion of current and also correct the power factor to unity with balanced and unbalanced loads.

N. Mendalek, K. Al-Haddad, F. Fnaiech and L. A. Dessaint et al. [6] have showcased the modelling of and a nonlinear control strategy for, a three-phase voltage source shunt active power filter. The dynamic model is initially elaborated in the system ‘abc’ and then transformed into the synchronous orthogonal ‘dq’ frame. The ‘dq’ frame model is divided into two separate loops, namely the two current dynamics inner loop and the DC voltage dynamics outer loop. The exact feedback linearization theory is applied in the design of the controller. Then, the pole placement strategy is used to synthesize the closed loop error dynamics of current tracking and DC bus voltage regulation. The adopted control strategy allows the decoupling of the currents and improves their tracking behavior and enhances DC voltage regulation and also the controller is capable of compensating under severe load current imbalances.

Hoon Y., Mohd Radzi, M.A. Hassan, M.K. Mailah N.F.et al. [7] Current harmonics is one of the most momentous power quality issues which has attracted remarkable research attention. Shunt active power filter (SAPF) is the best solution to minimize harmonic contamination, but its effectiveness is strictly dependent on how quickly and accurately its control algorithms can perform. This paper showcases various types of existing control algorithms which have been employed for controlling operation of SAPF. Harmonic extraction, DC-link capacitor voltage regulation, current control and synchronizer algorithms are observed and conferred. The most relevant techniques which have been applied for each control algorithm are described and contrasted in an organized manner to identify their respective strengths and weaknesses. It is found that the applied control algorithms differ in two conditions: (1) the condition where harmonic current distortion is treated by the SAPF in the presence of non-ideal source voltage; and (2) the condition where multilevel inverter is employed as the circuit topology of SAPF.

H. Jou, J. Wu and H.Chu et al. [8] presents a new algorithm for a single-phase active power filter, based on calculation of the real part of the fundamental load current. The proposed algorithm can maintain the input power factor of the mains close to unity and force the mains current to be a sine wave under distorted or non-distorted mains voltage. For testing this, a prototype is developed and its performance is verified. It depicts that the algorithm proposed can compensate for the reactive power and suppresses the harmonics of the nonlinear load effectively.

III.CONCLUSION

Total harmonic distortion is determined by FFT analysis, and a Simulink model is developed to analyse current breakdown based on instantaneous power theory for shunt active power filters. The active power filter used here is continually sensitive to variations in load harmonics and monitors the load current. Utilities companies eventually will convince customers with nonlinear loads to install AFs so that power quality may be maintained at a reasonable level.

Harmonic current, reactive power, neutral current, unbalance current, and harmonics may all be compensated using one of many different AF setups. Buyers may choose the AF that best suits their needs. The results of this study of AFs are intended to serve as a resource for both consumers and suppliers.

IV.References

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