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Reactive power management system to improve the power factor and reduce the transmission line losses

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ABSTRACT

In this paper, an understanding of reactive power associated with power transmission networks is developed. To make transmission networks operate within desired voltage limits, methods of making up or taking away reactive power - hereafter called reactive-power control – are discussed. Before proceeding further, however, a thorough understanding of the reactive power in ac systems is necessary. The Reactive power management play an important role in voltage profile of the power transmission systems. Adequate reactive power control solves power quality problems like flat voltage profile maintenance at all power transmission levels, improvement in power factor, transmission efficiency and system stability. The Series and shunt Capacitor compensation techniques are used to modify the natural electrical characteristics of the electric power system. Providing reactive shunt compensation with shunt-connected capacitors and reactors in optimal location is a well-established technique to get a better voltage profile in a power system. This paper is not intended to provide a comprehensive analysis of transmission lines. Rather, its objective is to examine those aspects that enhance the understanding of the interplay between voltages on the line and the resulting reactive-power flows.

Keywords: Reactive Power, Voltage stability, Voltage Collapse, Power system security, Voltage control.

INTRODUCTION

Today, the situation on low voltage AC systems has become a serious concern. The quality of electrical power in commercial and industrial installations is undeniably decreasing. In addition to external disturbances, such as outages, sags and spikes due to switching and atmospheric phenomena, there are inherent internal causes specific to each site and resulting from the combined use of linear and non-liner loads. Untimely tripping of protection devices, harmonic overloads, high levels of voltage and current distortion, temperature rise in conductors and generators all contribute to reducing the quality and the reliability of a low-voltage AC system. The current drawn from the AC mains has variable power factor, low efficiency, voltage and current distortion, interference in some instruments and communication equipment by the EMI, over heated transformers and electromagnetic fields and increased losses in transmission and distribution systems. [1]

The above unwanted disturbances are well understood and directly related to the proliferation of loads consuming non- sinusoidal current, referred to as "non-liner loads". This type of load is used for the conversion, variation and regulation

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of electrical power in commercial, industrial and residential installation [2].

Harmonic contamination and poor Power Factor have become a major concern for power system specialists due to its effects on sensitive loads and on the power distribution system. Therefore the compensation for harmonic and reactive current is important owing to the wide use of power electronic equipment's. A classical solution is suitable power conditioning methodology such as passive filtering and active power filtering to suppress harmonics in power systems. Passive LC filters have been employed to eliminate line current harmonics and to improve the power factor. However, the harmonic problems still persists because of its inability to compensate random frequency variations in currents, tuning problems and parallel resonance. Hence a very interesting solution is shunt active power filter, which is connected in parallel with the non – liner loads. The active power filter concept uses power electronics to produce harmonic components, which cancel the harmonic components from the non-liner loads. Recently parallel connected-type active power filters have been developed for useful method of harmonic current compensation [3-9].

These active power filters are normally classified into two types on the basis of current detection methods.

- Load current detection
- Supply current detection

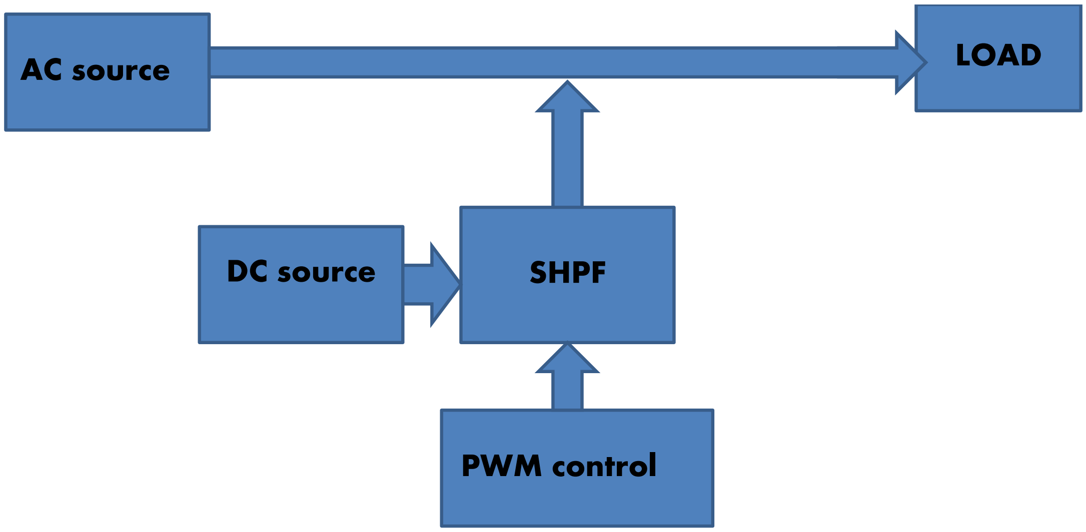
The former, which is popular than the latter suppresses the source current harmonics indirectly with detecting the load current harmonics. The latter detects the source current and suppresses the source current harmonics directly [10-15].

Load current detection and supply current detection are suitable for shunt active power filter installed in the vicinity of one or more harmonic – producing loads by individual high-power consumers. This paper will focus on the design, fabrication and the control methodology for a shunt active power filter. This method has the advantages of using only limited number of sensors, a simple control circuit and low implementation cost. A prototype is also developed to demonstrate the performance of this method. The test results show that the proposed active power filter has the expected performance. The active power filter is able to compensate the displacement of the input current in relation to the AC mains voltage and the harmonics components of single & multiple non – liner load, through the sensing of the load current, which is the current controlled VSI PWM control technique [16-21].

Active harmonic conditioners are proving to be viable option for controlling harmonic distortion levels in many applications.

CONVENTIONAL METHOD

In this Method the power factor correction made by the capacitor bank controller it so not adaptive control so error solution will not be accurate .Power factor is less than 0.9



In the present technological revolution power is very precious. So we need to find out the causes of power loss and improve the power system. Due to industrialization the use of inductive load increases and hence power system losses its efficiency. So we need to improve the power factor with a suitable method of automatic power factor correction. This study undertakes the design and simulation of an automatic power factor correction that is developed using arduino microcontroller PIC Microcontroller. Automatic power factor correction device reads power factor from line voltage and line current. This time values are then calibrated as phase angle and corresponding power factor. The display used was 4x16 liquid crystal display module. The motherboard calculates the compensation requirement and accordingly switches on different capacitor banks will run. This automatic power factor correction technique can be applied to the industries, power systems and also households to make them stable and due to that the system becomes stable and efficiency of the system as well as the apparatus increases. The use of microcontroller reduces the costs and the customers become beneficial according to the simulated output because the power factor of the specific selected industry is corrected from 0.66 to 0.84 improved value

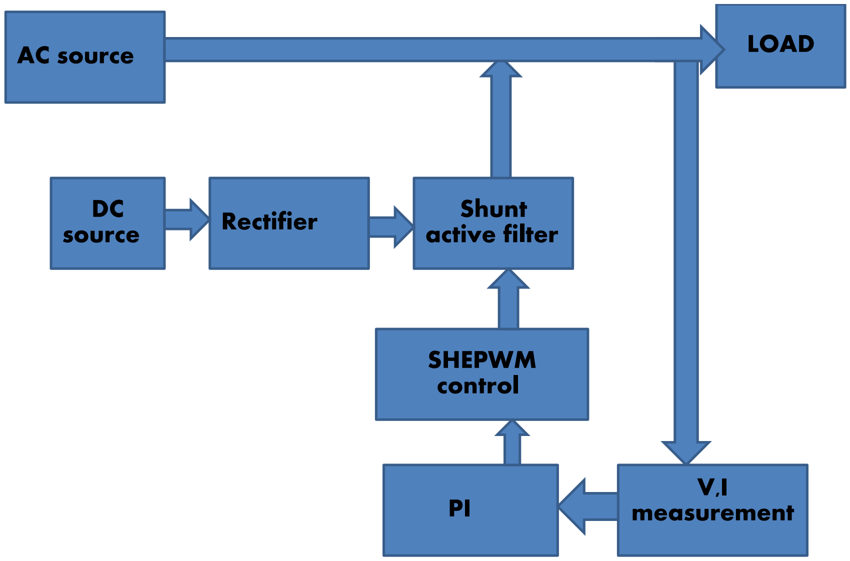
PROPOSED METHOD

The main application of power electronic equipment is to increase the results of poor power quality of system. Load harmonics current reduces the power quality supplied by power system. Due to current harmonics has become a major problem for the utilities at distribution levels. The non-sinusoidal voltage and current adversely affects on the performance of various electrical equipment connected in the system. Thus, it is necessary to eliminate these harmonics present in voltage and current in various parts of the power system. This paper presents a three phase shunt active filter connect at point of common coupling distortion in Power System. In order to improve the power factor, compensation of total harmonics distortion drawn from a three phase diode bridge rectifier load. Synchronous d-q reference frame is used for generation of reference current for the shunt active filter.

- We implemented shunt active filter so power factor improving accuracy is more then 0.99
- By using SHEPWM THD also reduced to below3%
- Efficiency is high.

The active conditioner may be installed at different points on AC distribution systems close to the loads generating high level of harmonics to ensure local compensation of harmonic currents, partial compensation of harmonic currents centrally at the PCC level, for global compensation of harmonic currents Ideally, compensation of harmonics should take place at their point of origin.

A number of cost and technical criteria are used to make the best selection. Mains advantages of the local compensation avoid dissemination of the harmonic currents in the electrical installation reduce Joule effect losses in the cables, and load on the main transformer reduces size of the cables required in new installations means installation can meet applicable harmonic Standards.



WORKING

The block diagram of the proposed shunt active power filter consists of the main circuit, the control circuit and reference current extraction circuits. Shunt active power filters are used to eliminate the unwanted harmonics and compensate power factor by injecting equal but opposite harmonic compensation currents. An active power filters acts a current controlled voltage source inverter, connected in parallel with the non linear load, is controlled to generate the required compensation currents, so the mains only needs to supply the fundamental current and of good quality. Based on the above fundamental concept, the non-liner load current is sensed by a current transducer. The sensed current is passed through an extraction circuit to filter out fundamental components of the load current, thus the output of extraction circuit is signal containing purely the harmonics components of load current. This signal is used as a reference signal to PWM signal generation. The proposed method of shunt active power filter and its control strategy is explained step by step.

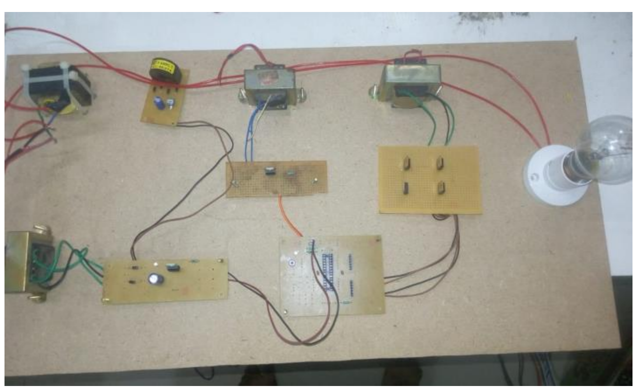
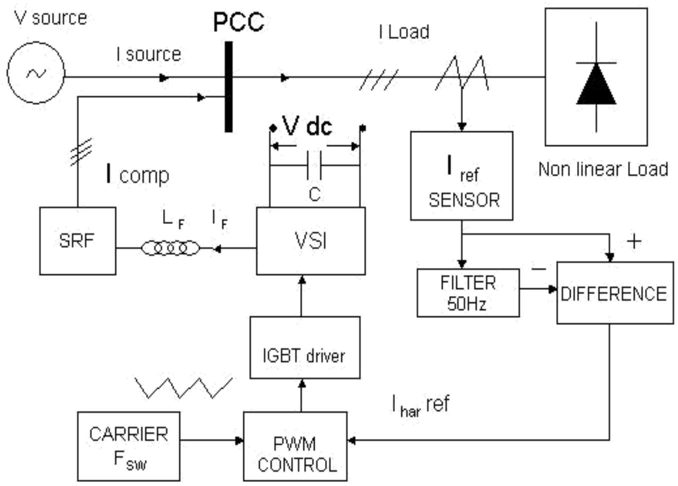


Fig. Hardware for Reactive Power Management System to Improve the Power Factor and Reduce the Transmission Line losses



Functional block diagram of shunt active power filter

Calculation of harmonic current reference

The APF control scheme is based on a harmonic current reference (Iref) extracted from the nonlinear load current by using either band pass filter with difference amplifier on 50Hz twin – T notch filter to filter out power line hum

Harmonicextraction circuit using band pass filter approach

Based on fundamental concept, the non- liner load current IL is passed through a Band Pass filter to filter out fundamental components of the IL. Then the extracted fundamental component is subtracted from the total harmonic load current. Now, the output of the extraction circuit is a signal containing purely the harmonic component of load current.

Realization of Bisque filtering method is used as the extraction topology. This method used a Tow-Thomas bisque Band-Pass Filter and Difference Amplifier circuit. The Band Pass filter is designed to be 50Hz with Unity Gain and Quality factor of 5.

This harmonic signal is used to control the firing topology of the PWM VSI. It is a single-phase representation we can extend for three phases with same logic. From circuit, band pass filter design is given by

- Resonant frequency Wo=1/RC, Fo=50Hz
- Q factor = R1/R3
- Gain = R1/R4 = 1, R1=R4,
- C1= C2 = C, & R2 = R3

RESULTS AND DISCUSSION

In order to confirm the effectiveness of the shunt active power filter with the proposed control strategy is confirmed by an experimental system shown in Figures. 7.1to 7.4. A single phase 220V, 50Hz low power model consisting of a 2KVA rectifier fed either R or RL load acts as a nonlinear load and an 1KVA Voltage source active power filter has been developed in power electronics laboratory. The control circuit has been realized by using analogical devices, resulting in a fast signal processing. Tests were performed in different cases of variable load conditions.

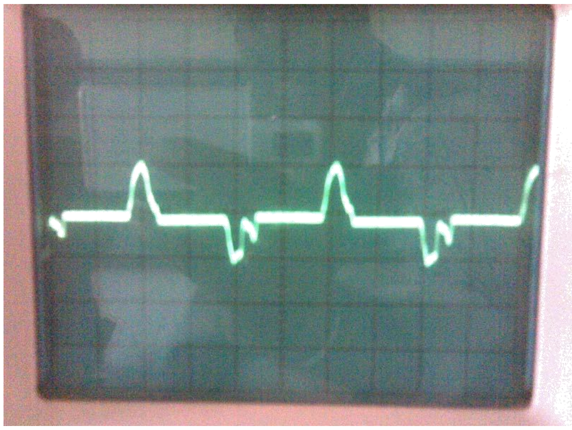


Figure.7.1 Extracted harmonic load current with Vs=220V and Is = 2A

Figure 7.1 which presented the experimental circuits of the active filter compensating a 2000w nonlinear load, which consists of an uncontrolled rectifier with C filter.

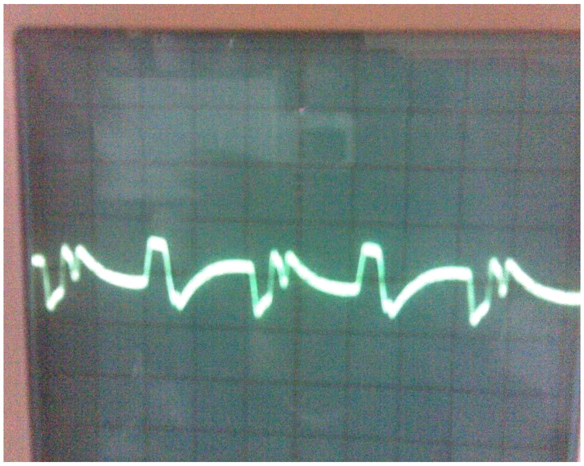


Figure.7.2Generation of Triangular Carrier Wave

The performance of source voltage and source current with different conditions is presented in figure7.2. It shows that the extracted harmonic and fundamental current from the source current the gain and quality factor of either band pass or 50 Hz Notch filter is imperfectly tuned then the fundamental source current and harmonic current is distorted, hence correct harmonic reference is not obtained.

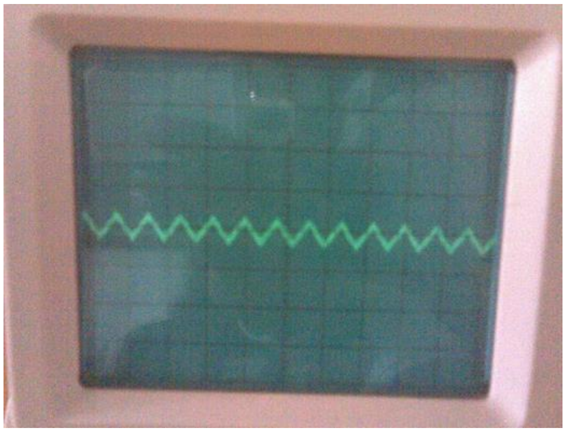
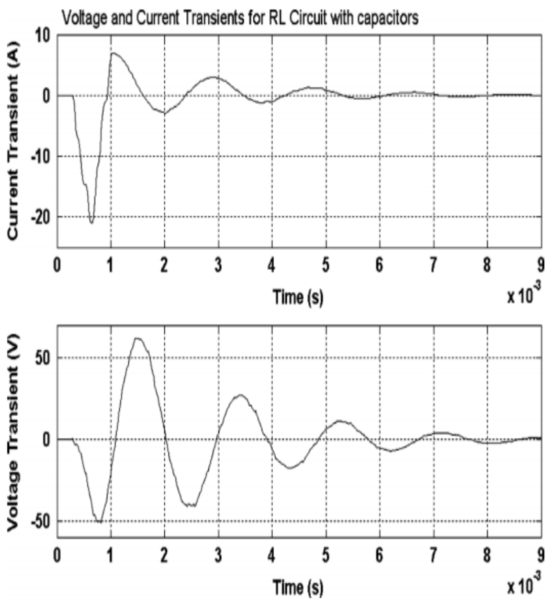


Figure.7.3 Effect of load current before active power filter is installed

Figure.7.3 shows that the generation of triangular wave with switching frequency of 3 to 20KHz and Generation of PWM

Figure.7.4 Effect of load current after active power filter is installed

FINAL OUTPUT WAVEFORM



From figure 7.3 and 7.4 switching signal with comparison of Harmonic current reference with Triangular carrier wave resulting in PWM pulses with which average values gives harmonic current reference. This PWM pulses is given to the PWM inverter switches after amplification with suitable driver circuit, which produces output voltage of +/- Vdc whose average values gives harmonic current reference with amplifying magnitude of current resulting waveform shown extracted fundamental and load current with different values of varying load condition and the final output waveforms show that the nature of source voltage and source current with different values of varying load condition and also the values of total harmonic voltage and current distortion with input power factor is noted with the help of power quality analyzer before active power filter is connected in parallel with the harmonic producing load. Finally in order to verify the performance of designed shunt connected active power filter which is connected in parallel with the harmonic producing loads then resulting waveform of source voltage and source current with different condition of load current given in same condition of without active power filter is measured resulting waveform obtained.

CONCLUSION

Since power electronics related equipment has been widely used in recent years, the harmonic pollution of power systems is more serious than before. To overcome this problem, the harmonic restriction has become strict. The harmonic limitation in more country is not only of the voltage but also the current. The active power filter is anew and effective solution for harmonic related problems.

In this work a simple and efficient control block to generate reference current templates and PWM switching technique for active power filters is implemented and tested. The controller eliminates the unwanted harmonics and correction supply power factor. And another interesting characteristic of the proposed method of control is that multiplications, divisions and transformation are eliminated, making the control system cheap simple and reliable, care should be taken only in the design of filter inductance and switching ripple filter. This type of harmonic filter allows the harmonics present in the utility system to be filtered out without jeopardizing the stability of the system and hence providing a good quality of power supply to the customer side.

This type of Active power filters provides a cost-effective, reliable, and flexible solution for power quality Control. Since the APF only processes the reactive and harmonic current, power loss and component rating is typically lower when compared to other power factor correction methods. This technique is particularly well suited to applications with multiple power supplies and reactive loads. For existing nonlinear loads, near unity power factor can be achieved by simply connecting and APF device in parallel with the AC inlet. From the above analysis and test results, it can be found that the proposed method has all the performance of conventional active power filters. Besides the compensation current is still a sine wave regardless of whether the mains voltage is distorted or non-distorted.

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