An Improved technique for harmonic reduction with PI controller using shunt active power filer

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Abstract— *As today maximum load are power electronic equipment, the degradation of the power quality in the utility networks is increased and is become a serious problem. Limiting the current distortion is therefore a concern for both utilities and consumer. major sources of harmonics are Electronic device such as rectifiers, power supplies and at a higher power level, arc furnaces. This harmonics can be suppressed by using the shunt active filter. There are many control strategies to reduce harmonics. in this paper the improvement of power quality in three phase four wire system with balanced and unsteady source condition based on three phase shunt active power filter. The PI controller is used to regulate the DC relationship between voltage. Synchronous reference frame (SRF) method is used for extracting reference current. The pulse width modulation (PWM) controller is used to generate gate pulses and applied to three phase VSI based shunt active power filter with split capacitor topology. Mainly the aim of this paper is to reduce the total harmonic distortion (THD) in the source current. The MATLAB/Simulink is used for model of three phase source and nonlinear load is connected to the system.*

Keywords— Harmonic Compensation, Shunt Active Power Filter, PI Controller, Multilevel inverter, Space Vector Pulse Width Modulation Control Strategy

I. INTRODUCTION

Wind Early equipment was designed to withstand disturbances such as lightning, short circuits, and sudden overloads without extra expenditure. Current power electronics (PE) prices would be much higher if the equipment was designed with the same robustness. Pollution has been introduced into power systems by nonlinear loads such as transformers and saturated coils; however, perturbation rate has never reached the present levels. Due to its nonlinear characteristics and fast switching, PE create most of the pollution issues. Most of the pollution issues are created due to the nonlinear characteristics and fast switching of PE. Approximately 10% to 20% of today's energy is processed by PE; the percentage is estimated to reach 50% to 60% by the year 2010, due mainly to the fast growth of PE capability. A race is currently taking place between increasing PE pollution and sensitivity, on the one hand, and the new PE-based corrective devices, which have the ability to attenuate the issues created by PE, on the other hand. Increase in such non-linearity causes different undesirable features like low system efficiency and poor power factor. It also causes disturbance to other consumers and interference in nearby communication networks. The effect of such non-linearity may become sizeable over the next few years. Hence it is very important to overcome these undesirable features. Classically, shunt passive filters, consist of tuned LC filters and/or high passive filters are used to suppress the harmonics and power capacitors are employed to improve the power factor. But they have the limitations of fixed compensation, large size and can also exile resonance conditions. Active power filters are now seen as a viable alternative over the classical passive filters, to compensate harmonics and reactive power requirement of the non-linear loads. The objective of the active filtering is to solve these problems by combining with a much-reduced rating of the necessary passive components. Various topologies of active power filters have been developed so far. The shunt active power filter based on current controlled voltage source type PWM converter has been proved to be effective even when the load is highly non-linear. Most of the active filters developed are based on sensing harmonics and reactive volt-ampere requirements of the non-linear load and require complex control. A new scheme has been proposed in, in which the required compensating current is determined by sensing load current which is further modified by sensing line currents only. An instantaneous reactive volt-ampere compensator and harmonic suppressor system is proposed without the use of voltage sensors but require complex hardware for current reference generator. However, the conventional PI controller was used for the generation of a reference current template. The PI controller requires precise linear mathematical models, which are difficult to obtain and fails to perform satisfactorily under parameter variations, nonlinearity, load disturbance, etc.

II. PROBLEM IDENTIFICATION

Problem of Power is not about harmonic only, but is about the distortion to the supply voltage and its effects on the equipment connected to it either directly or indirectly. There are many types of problems (disturbances) which may affect the power quality. Some of these problems are severe but rare while others could be not that critical however they are more frequent. Among the electric power quality problems, the following are distinguished: transients, harmonics, sags, swells, flicker, unbalances notches, frequency variations and high-frequency noise. Some of these power quality problems are investigated in more depth showing causes and effects of such problems and some recommendations on how to eliminate them.

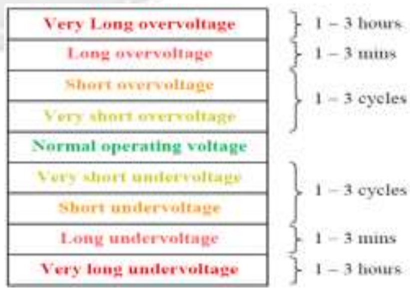

Fig. 1: Magnitude-duration for classification of PQ

III. Methodology

The shunt-connected active power filter, with a self-controlled dc bus, has a topology similar to that of a static compensator (STATCOM) used for reactive power compensation in power transmission systems. Shunt active power filters compensate load current harmonics by injecting equal-but opposite harmonic compensating current. In this case the shunt active power filter operates as a current source injecting the harmonic components generated by the load but phase-shifted by 180°.

The flowchart in Fig 3 shows the Initialization process and two steps of operation. Initialization process searches for a kopt with boost circuitry approach. Step 1 retains the system at the detected maximum, unless there is a change observed in wind velocity v. Step 1 gets into action under changing wind conditions and implements the novel Optimal Point search method via the earlier found kopt.

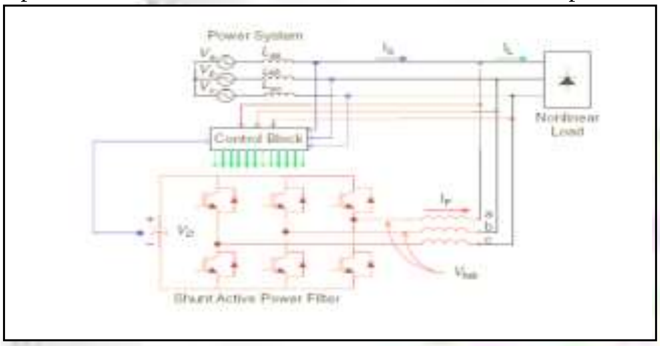

Fig. 2: Shunt active power filters topology

IV. Proposed Control Strategies

A. PI CONTROL SCHEME

The complete schematic diagram of the shunt active power filter is shown in figure 3. While figure 4 gives the control scheme realization. The actual capacitor voltage is compared with a set reference value.

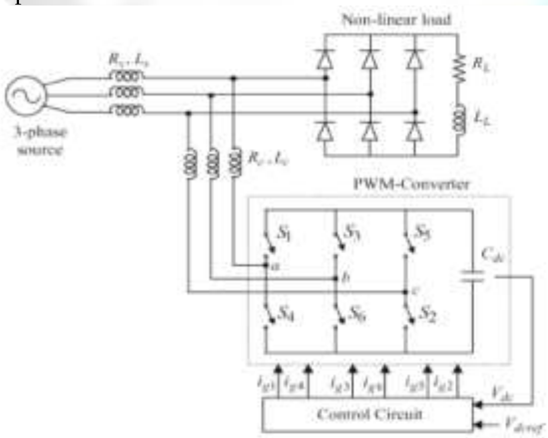

Fig. 3: Schematic diagram of shunt active filter

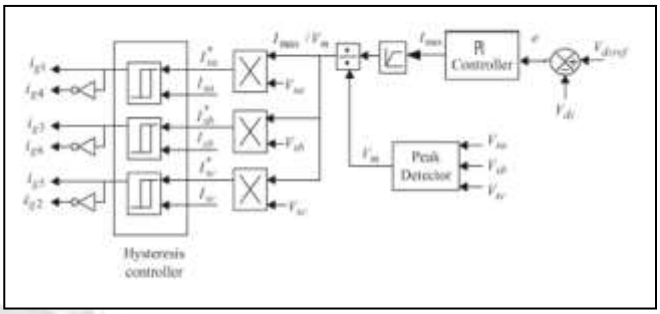

Fig. 4: APF Control scheme with PI controller

The error signal is fed to PI controller. The output of PI controller has been considered as peak value of the reference current. It is further multiplied by the unit sine vectors (u_{sa}, u_{sb}, and u_{sc}) in phase with the source voltages to obtain the reference currents (i_{sa}^*, i_{sb}^*, and i_{sc}^*). These reference currents and actual currents are given to a hysteresis based, carrier less PWM current controller to generate switching signals of the PWM converter. The difference of reference current template and actual current decides the operation of switches. To increase current of particular phase, the lower switch of the PWM converter of that particular phase is switched on, while to decrease the current the upper switch of the particular phase is switched on. These switching signals after proper isolation and amplification are given to the switching devices. Due to these switching actions current flows through the filter inductor L_c, to compensate the harmonic current and reactive power of the load, so that only active power drawn from the source.

V. Matlab Simulink

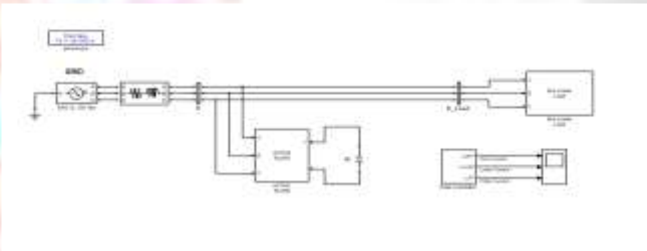

Fig. 5: Simulink model of PI controller using shunt active power filer

VI. Result & Discussion

A program is developed to simulate the both PI controller based and shunt active power filter in MATLAB. The complete active power filter system is composed mainly of three-phase source, a nonlinear load, a voltage source PWM converter, and a fuzzy controller or a PI controller. All these components are modeled separately, integrated and then solved to simulate the system.

Figures shows the simulations results of the proposed shunt active power filter controlled by logic and a conventional PI controller with MATLAB program. The three phase source voltages are assumed to be balanced and sinusoidal. The source voltage waveform of the reference phase only.

A load with highly nonlinear characteristics is considered for the load compensation. The THD in the load current. The phase-a load current is shown. The source current is equal to the load current when the active filter is not connected… Figure 6.

CASE 1(WHEN ACITVE FILTER IS NOT CONNECTED)

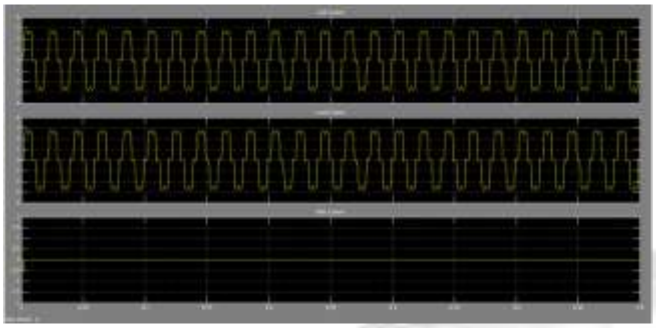

Fig 6: Output waveform when active filter is not connected

From the wave forms it is clear that harmonic distortion is reduced after connecting active filter. Compared to PI controller gives better harmonic compensation. The system studied has also been modeled using simulink and performance of PI and Filter controllers is analyzed..figure 7

CASE 2 (WHEN ACITVE FILTER IS CONNECTED)

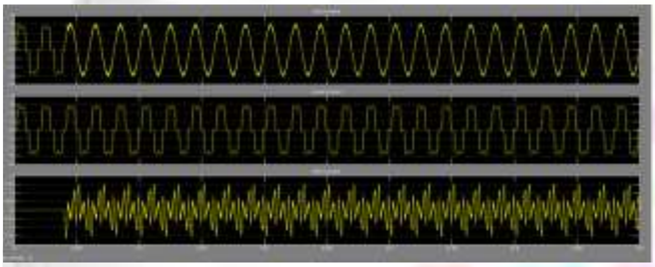

Fig 7: Output waveform when active filter is connected

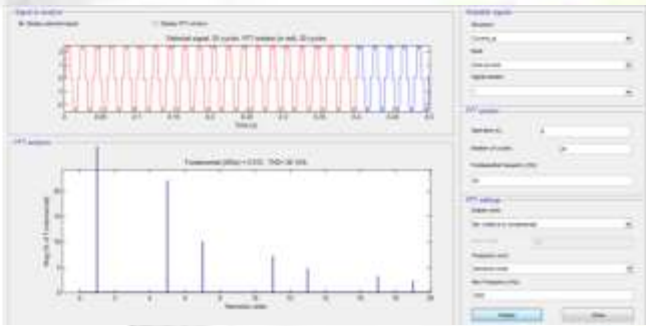

Fig 8: THD without Active Shunt Filter

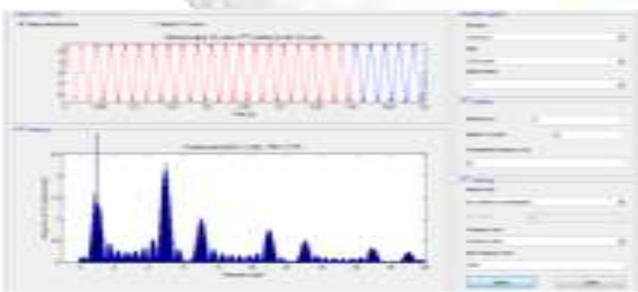

Fig 9: THD with Active Shunt Filter

VII. Conclusion & Future Scope

A shunt active power filter has been investigated for power quality improvement. Various simulations are carried out to analyze the performance of the system. Both PI controllers based and fuzzy logic controller based Shunt active power filter are implemented for harmonic and reactive power compensation of the non-linear load. A program has been developed to simulate the PI controller based shunt active power filter in MATLAB. It is found from simulation results that shunt active power filter improves power quality of the power system by eliminating harmonics and reactive current of the load current, which makes the load current sinusoidal and in phase with the source voltage. The performance of both the controllers has been studied and compared.

A model has been developed in MATLAB SIMULINK and simulated to verify the results. The controller based shunt active power filter has a comparable performance to the PI controller in steady state except that settling time is very less. Experimental investigations can be done on shunt active power filter by developing a prototype model in the laboratory to verify the simulation results for both.

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