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Analysis of Power Quality Improvement Using Shunt Active Power Filter

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Abstract - *In the present work another control algorithm dependent on Instantaneous power theory (p-q theory) for three phase four wire is taken for a Shunt Active Power Filter (SAPF) to compensate harmonics and reactive power and power factor of a three phase nonlinear load, uncontrolled bridge rectifier. Detecting load currents, dc transport voltage and source voltages process reference currents of the SAPF. Driving signs of SAPF are delivered by taking care of reference and genuine output current of APF, to hysteresis band current regulator. As proposed model contains three phase four wire framework neutral current compensation likewise taken consideration by SAPF. Here in this paper two cases are considered of various load circumstance at rectifier side, for example, nonlinear load alone and unbalance load with nonlinear load. It is tracked down that under both the load cases the SAPF is exceptionally successful answer for current harmonics, reactive power compensation and power factor correction. MATLAB / SIMULINK power system toolbox is used to simulate the proposed system.*

Key Words: Eliminating the harmonics, Shunt Active Power Filter (SAPF), p-q theory, Active filters.

1. INTRODUCTION

Recently, wide use of nonlinear and time-shifting gadgets has prompted distortion of voltage and current waveforms in ac organizations. Thus, harmonics, sub-harmonics and inter-harmonics are frequently present in voltage and current spectra. Passive filters are conventional answers for moderate harmonics yet the constraint of passive filters for repaying has made active filters attractive. The passive filters have been utilized as a regular answer for tackle harmonic currents issues, however they present a few disadvantages: they just filter the frequencies they were recently tuned for; its activity can't be restricted to a specific load or group of loads; resonance can happen because of the communication between the passive filters and others loads, with unexpected outcomes. To adapt to these drawbacks, ongoing endeavours have been focused on the advancement of active power filters. In this paper the improvement of a shunt active filter is proposed, with a control framework dependent on the p-q theory. With this filter it is feasible to adequately remunerate the harmonic currents and the reactive power.

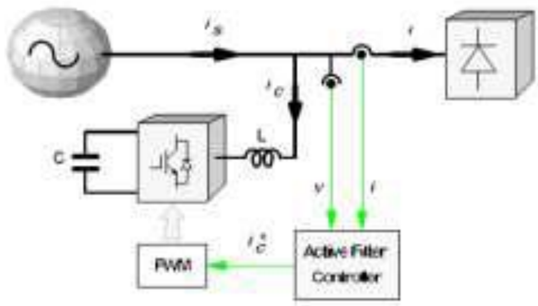

Fig -1: Schematic diagram of shunt active filter

Active power filters are adaptable and flexible answer for voltage quality issues. Improvement of technologies gave to ac induction machine drive and, specifically, acknowledgment of quick electronic switches has built up the utilization of active filters for harmonic and power factor compensation. A few works on active filter controllers dependent on synchronous reference outline transformation are carried out. Shunt active filters utilizing traditional control strategies have effectively been utilized to make up for basic power quality issues like current harmonics, reactive power and load imbalance.

Shunt active power filters are normally carried out with pulse-width modulated voltage source inverters. In this sort of uses, the pwm-vsi works as a current controlled voltage source and compensates current harmonics by soaking-in equal however inverse harmonic compensating current. An extremely important topic for shunt active filter design is the selection of a compensating strategy, that is, the method for testing the reference compensating current. Different current control ways of were proposed for shunt active filter. Hysteresis current control method is the most popular one in terms of quick current controllability, versatility and easy implementation.

2. Literature Survey

1) "Shunt Active and Series Active Filters-Based Power Quality Conditioner for Matrix Converter" by P. Jeno Paul discussed in a paper that proposes a series

active filter and shunt active filter to minimize the power quality impact present in matrix converters instead of passive filter. A matrix converter produces significant harmonics and nonstandard frequency components into load. The proposed system compensates the sag and swell problems efficiently in matrix converter. The proposed system has been tested and validated on the matrix converter using MATLAB/Simulink software. Simulated results confirm that the active power filters can maintain high performance for matrix converter.

2) "Power Quality Improvement Using Shunt Active Power Filter" by Sagar S. Patil & R. A. Metri discussed that power electronics devices have evolved, and used for varies applications. Also, this device caused the problem of power quality in electrical system. In the utility side arc furnaces, variable frequency drives (VFD), personal computer, fluorescent lamp such non-linear load produces current harmonics. For consumer and distributed side the power quality is an important issue. The active power filter which is capable for improving the power quality and reactive power compensation. In this paper the harmonics problem which is created by non-linear load is discussed. Shunt active filter is used for eliminating the harmonics from non-linear load and in the retrieval technique for controlling the current hysteresis current controller is used. In this paper for producing the reference current instantaneous reactive power (PQ) theory is used. The simulation result of shunt active filter using PQ theory is carried out using matlab-simulink toolbox.

3) S. Rajasekaret al. (2011) proposed an objective of this paper is to develop and analyse the compensation characteristics of cascaded multilevel inverter based shunt hybrid active power filter by employing indirect current control algorithm. The indirect current control algorithm is employed to generate reference current and phase disposition pulse width modulation technique is incorporated to generate gating signal for shunt hybrid active power filter strategy. The nonlinear loads are connected to distort the source current to 21% of harmonics distortion, as per IEEE 519 allowable current harmonic distortion is 5%. To mitigate harmonic distortion, cascaded multilevel inverter based shunt hybrid active power filter is proposed and after compensation the source current harmonic distortion is reduced to 2.93%. The simulation analysis is carried out using SIMPOWERSYSTEMS block set of MATLAB/SIMULINK to determine which of the inverter topology based shunt hybrid active power filter strategy perform better on compensating source current harmonic distortion.

4) Mohamed Halawa et al. (2016) proposed one of the main power quality concerns currently is the existence of harmonics. Shunt active power filters are widely applied in power distribution grids to mitigate current harmonics and compensate the reactive power. In this paper the instantaneous reactive power theory is used to detect reference compensation current for the controller of the shunt active filter and a hysteresis current controller is used to synthesize it precisely. Hysteresis current controller is one of the simplest current control methods and the most popular one for active power filter applications, but it suffers from an uneven switching frequency, to overcome this disadvantage a novel fuzzy hysteresis current controller is being used. The proposed controller is characterized by simplicity as a result of reducing the size of calculations that makes it acting faster and doesn't rely on the load parameters. The system was modelled and simulated using MATLAB/SIMULINK. The results of simulation are presented and discussed they show the effectiveness of the proposed fuzzy hysteresis controller in improving the PWM performance and thus improve the shunt active power filter performance.

5) Sumit Bhattacharya et al. (2017) proposed a Multi-Level Inverter (MLI) based Shunt Active Power Filter(APF) is represented in this paper. SingleMLI-APF is used as both Interfacing converters for improvement of Power Quality of the Whole system. Use of MLIs reduces stress on power electronic devices because they can be made to operate at low voltages compared to the conventional two level converters. The output voltage provided by MLIs has small voltage steps, that results in good power quality and low-harmonic components. As Majority of the Renewable systems comprises at least two converters for these tasks, the proposed system may be treated as simple and economical in meeting the same objectives. Peak detection method of

control strategy is employed in MLI-APF for power quality improvement. The proposed system is simulated using MATLAB/SIMULINK and tested for power quality improvement.

3. SYSTEM CONFIGRATION

The arrangement of shunt active power filters (SAPF) configuration circuit. The The arrangement of shunt active power filters (SAPF) configuration circuit which is connected on shunt with the load. The load is non- linear like personal computer, inverter and so on. This is produce current harmonics in the system the course of action of shunt active filter contain of injects harmonic current with an almost the same magnitude yet inverse phase for utility side. shunt active filter contains of pulse width modulation for three phase system (PWM), inverter of voltage source (VSI) and ripple filter.

4. Classification of Active Filters

A. Classification based on objective:

Who is Responsible for Installing Active filters? The objective of —who is responsible for installing active filters classifies them in to the following two groups:

A) Active filters of installed by individual consumer on their own premises near one or more identified harmonic producing loads

B) Active filters installed by electrical power utilities in substation and /or on distribution feeders.

The main reason for the active filter introduced by every single consumers is to compensation for harmonics and current imbalance of their own harmonic creating loads. On the other hand ,the main role of active filter introduced by utilities soon is to make up for voltage harmonics and voltage imbalance, or to give harmonic damping all through power distribution framework. Moreover active filters have the capacity of harmonic isolation at the utility – consumer point of basic coupling in power distribution system.

B. Classification by System Configuration:

Shunt Active Filters and Series Active Filters:

A system a system configuration of a shunt active filter used alone, presents the electrical scheme of a shunt active filter for a three-phase power system with neutral wire, which is able to compensate for both current harmonics and power factor. Furthermore, it allows load balancing, eliminating the current in the neutral wire. The power stage is, basically, a voltage-source inverter with only a single capacitor in the DC side (the active filter does not require any internal power supply), controlled in a way that it acts like a current-source. From the measured values of the phase voltages (va, vb, vc) and load currents (ia, ib, ic), the controller calculates the reference currents (ica*, icb*, icc*, icn*) used by the inverter to produce the compensation currents (ica, icb, icc, icn). This solution requires 6 current sensors and 4 voltage sensors, and the inverter has 4 legs (8 power semiconductor switches).For balanced loads without 3rd order current harmonics (three-phase motors, three-phase adjustable speed drives, three-phase controlled or non-controlled rectifiers, etc) there is no need to compensate for the current in neutral wire. These allow the use of a simpler inverter (with only three legs) and only 4 current sensors.It also eases the controller calculations.

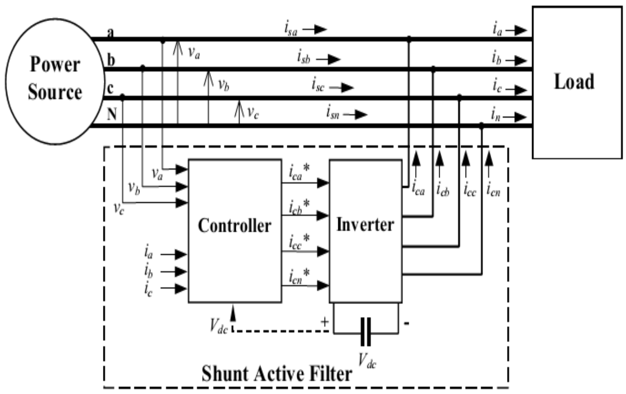

Fig-2 : Shunt active filter in a three-phase power system.

5. Power-Quality Theory(P-Q Theory)

Electric power quality is the degree to which the voltage, frequency, and waveform of a power supply system conform to established specifications. Good power quality can be defined as a steady supply voltage that stays within the prescribed range, steady a.c. frequency close to the rated value, and smooth voltage curve waveform (resembles a sine wave). In general, it is useful to consider power quality as the compatibility between what comes out of an electric outlet and the load that is plugged into it. The term is used to describe electric power that drives an electrical load and the load's ability to function properly. Without the proper power, an electrical device (or load) may malfunction, fail prematurely or not operate at all. There are many ways in which electric power can be of poor quality and many more causes of such poor quality power.

The electric power industry comprises electricity generation (AC power), electric power transmission and ultimately electric power distribution to an electricity meter located at the premises of the end user of the electric power. The electricity then moves through the wiring system of the end user until it reaches the load. The complexity of the system to move electric energy from the point of production to the point of consumption combined with variations in weather, generation, demand and other factors provide many opportunities for the quality of supply to be compromised.

The *p-q* theory was proposed by Akagi et al. in 1983. The *p-q* theory is based on conversion of *a-b-c* coordinate into *α-β-0* coordinates and *α-β-0* coordinates into *a-b-c* coordinates, popularly known as Clark transformation and inverse transformation respectively. Basic block diagram of *p-q* theory. Generated compensating current will be:

$$I_{comp} = I_{source} - I_{load} \quad (1)$$

Where,
Icomp = Compensating current
Isource = Source current and
Iload = Load Current

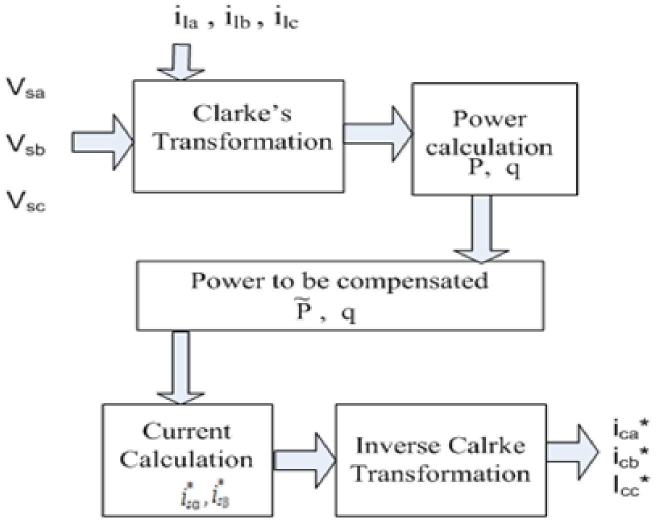

Fig-3: Basic block diagram of *p-q* theory

6. CONCLUSIONS

In this technique, another APF control scheme has been proposed to improve the performance of APF under non-ideal mains voltage conditions. The Personal Computer simulations in MATLAB need to confirm the adequacy of the proposed control scheme. Active power filters, in view of the proposed theory, give satisfactory activity in any event, when the framework phase voltages are unsymmetrical and distorted, the reason is that there is no distortion shows up in the line currents. In non-ideal mains voltage condition, the source currents by the instantaneous power (p–q) theory are distorted, however the source currents by the proposed technique have no distortion. The expanded performance of the APF under various non-sinusoidal mains voltage conditions is broadly illustrated. The APF is discovered compelling to fulfill IEEE 519 guideline suggestions on harmonics level in the entirety of the non-ideal voltage conditions. The presentation of the proposed level is in this manner better than that of ordinary three-stage APF control algorithm. Its control circuit is likewise easier that those of published non-ideal mains voltage algorithms. The unsymmetrical distorted voltage framework is the most extreme condition. In any case, great outcomes can be acquired by the proposed theory.

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