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A Review on Power Quality Improvement using Shunt Active Filter with Multilevel Inverter

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Abstract: Most of the pollution issues created in power systems are due to the non-linear characteristics and fast switching of power electronic equipment. Power quality issues are becoming stronger because sensitive equipment will be more sensitive for market competition reasons, equipment will continue polluting the system more and more due to cost increase caused by the built-in compensation and sometimes for the lack of enforced regulations. Efficiency and cost are considered today almost at the same level. Active power filters have been developed over the years to solve these problems to improve power quality. Among which shunt active power filter is used to eliminate and load current harmonics and reactive power compensation.

Keywords: Power quality, Shunt, Active filters, Multilevel inverters

Literature Survey:

S. Rajasekaret al. (2011) proposed an objective of this paper is to develop and analyze 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.

Saheb Hussain MD et al. (2011) This paper describes different power quality problems in distribution systems and their solutions with power electronics based equipment. Shunt, hybrid and series active power filters are described showing their compensation characteristics and principles of operation. Different power circuits topologies and control scheme for each type of active power filter are analyzed. The compensation characteristics of each topology with the respective control scheme are proved by simulation and experimentally.

A. Rajani et al. (2014) proposed Shunt Active Power Filter (APF) or Active Power Line Conditioner (APLC) is designed and implemented for power quality improvements in terms of current harmonics and reactivepower compensation. The widespread use of non-linear loads in industrial, commercial and domestic facilities cause harmonic problems. Active power line conditioner is implemented for compensating the harmonics and reactive-power simultaneously in the distribution system. This paper presents synchronous reference frame (SRF) controlled cascaded multilevel inverter based shunt active filter to suppress the harmonics as well as improving the power quality in distribution system Here filter is a low pass type in conjunction with proportional integral (PI) controller which is used to estimate the peak reference current and maintain the DC bus capacitor voltage of the cascaded inverter nearly constant. Here we observed the simulation results of total harmonic distortion, reactive power and etc.

K. Vasantha Sena(2014) proposed Interest of using shunt active power filters is increased in recent years. This paper presents aninnovative synchronous reference frame (SRF) controlled five-level and seven-level cascaded multilevel inverter based shunt active filter for power line conditioners (PLCs) to improve the power quality in the distribution system. Synchronous reference frame is used to control reactive power and harmonics compensation due to non-linear loads. The cascaded multilevel inverter is controlled by the triangular wave produced by the SRF. PI controller is used to maintain almost constant under transient and steady state condition. The proposed new model is simulated using MATLAB/SIMULINK and simulation results are demonstrated.

B.Raju et al. (2015) proposed A Multi-Level Inverter (MLI) based Shunt Active Power Filter(APF) is considered in this paper. Single MLI-APF is used as both Interfacing converter that processes and connects generated PV power to grid and also for improvement of power Quality of the Whole system. 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. 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. Peak detection method of control strategy is employed in MLI-APF for power quality improvement. The proposed system is simulated using MATLAB/SIMULINK.

Mr. Dipak Suresh Badgujar et al. (2015) proposed In the present work a new control algorithm based 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 . Sensing load currents, dc bus voltage and source voltages compute reference currents of the SAPF. Driving signals of SAPF are produced by feeding reference and actual output currents of APF, to hysteresis band current controller. As proposed model contains three phase four wire system neutral current compensation also taken care by SAPF. Here in this dissertation two cases are considered of different load situation at rectifier side, such as nonlinear load alone and unbalance load with nonlinear load. It is found that under both the load cases the SAPF is very effective solution for current harmonics, reactive power compensation and power factor correction. MATLAB / SIMULINK power system toolbox is used to simulate the proposed system.

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 modeled 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.

Sumit Kumar et al. (2016) proposed Improvement of Power quality is major concern in the field of power supply. Various methods have been adapted towards the improvement of power quality. Trend of improving it by using active power filter has been increased in recent years because of its simplicity. In this paper we have used the p-q reference theory as controller to control the output of active power filter to delete the harmonics and to compensate the power factor, PI controller is used to maintain almost constant value under transient and steady state condition. The harmonics occurred due to non linear load which draw current in abrupt manner rather than smooth way leads to create distorted signal on source side on the line which affect the other customers on the same line. By using the vdc as the reference current has been calculated and this reference current is compared with the actual current of active power filter, output from the pq theory is compared with actual current and applied to the gate signal of 3-arm universal bridge used in active filter to delete the harmonics. Hence by using the active power filter IEEE 519 standard which say “IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems” has been meet. The proposed model has been simulated using MATLAB/SIMULINK and simulation results.

AnithaBhukya et al. (2017) In recent decade, extensive applications of high power switching devices affecting the power quality significantly. In order to maintain a quality power mainly for sensitive loads, shunt Active Power Filter (APF) are often used, which improves the power factor and decreases the percentage of Total Harmonics Distortion (THD). The APF, when connected with the load generates an reference compensating current which is in phase opposition to the harmonics present in the system, thus the resultant supply current becomes sinusoid and in phase. The compensating reference current waveform is of complex in nature, and therefore a suitable inverter operated through high frequency switching is necessary for generation of such complex waveform. A multistage inverter could be more capable of generating such complex waveform as required for the compensating current. This work explores a three-Level and five-level Cascaded H-bridge (CHB) inverter for shunt Active Power Filter in Power System (PS) to compensate the reactive power and harmonics. The performance comparisons between three-level and five-level cascaded H-bridge (CHB) inverter for a shunt active power filter (APF) are presented.

Niklesh Das et al. (2017) proposed A power quality issue basically deals with any occurrence manifested in current, voltage or frequency deviation that results in damage, upset or failure of end use equipment. The non-linearity in the properties of power electronics devices and the higher switching frequency are the main causes of power quality issue. Thus this paper deals with power quality improvement by shunt active power filter to eliminate voltage and load current harmonics and for reactive power compensation. A shunt active power filter based on the instantaneous active and reactive current component (Id – Iq) method is proposed to compensate first harmonic unbalance. A theoretical studies based on synchronous detection method is done in this paper and the simulation results are analyzed regarding the harmonics compensation. Simulations are carried out with PI controller for the (Id – Iq) control strategies for different voltage condition using MATLAB/ SIMULINK.

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.

Conclusion: The filter presents good dynamic and steady-state response and it can be a much better solution for power factor and current harmonics compensation than the conventional approach (capacitors to correct the power factor and passive filters to compensate for current harmonics). Besides, the shunt active filter can also compensate for load current unbalances, eliminating the neutral wire current in the power lines. Therefore, this active filter allows the power source to see an unbalanced reactive non-linear load, as a symmetrical resistive load.

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