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Analysis of IGBT based Shunt Active Filter for Power Quality Improvement

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ABSTRACT: This paper focuses on harmonic mitigation techniques using a Shunt Active Power Filter (SAPF) to reduce harmonics within permissible limits. The major sources of harmonics in power systems are nonlinear loads, which cause various power quality issues such as voltage sag, swell, and flicker. To maintain system stability and improve power quality, a shunt active power filter is implemented in the modeled power system. The performance of the SAPF is highly dependent on its control strategy, which plays a crucial role in effective harmonic reduction. In this work, hysteresis control and phase control methods are employed as reference strategies for harmonic mitigation. The entire system is designed and simulated using MATLAB/Simulink, and the results are analysed to evaluate the performance of the proposed harmonic reduction techniques.

KEYWORDS: SAPF shunt active power filter, Phase control, Harmonics reduction, nonlinear loads, and PCC point of common coupling, Facts flexible AC transmission system devices.

I. INTRODUCTION

Technological advancements resulting in the extreme implementation of nonlinear loads in the power electronics field and this section has a much better scope for the researcher, engineer and others who are concerned for the harmonics interpretation in the power system. The harmonics current generated from the nonlinear loads will cause a significant power quality problems to the power system. This will degrade the power factor performance and may cause very severe problems in the power system. This will include overheating of system equipment's, errors in the measuring instruments, failures of sensitive devices and capacitor blowing. [1]

In order to eliminate the effects of harmonic currents IEEE standards has been set and it is clearly Indicated in the harmonic limits the total harmonic distortion for current will be maximum 5 %. As per the set target limits of 5% the designer and engineers are trying their best to achieve the target. In order to comply this target the conventional harmonic filters are applied and due to its major drawback of heavy size and fixed technique, innovative and efficient harmonic elimination tools known as active power filter are developed to replace them.

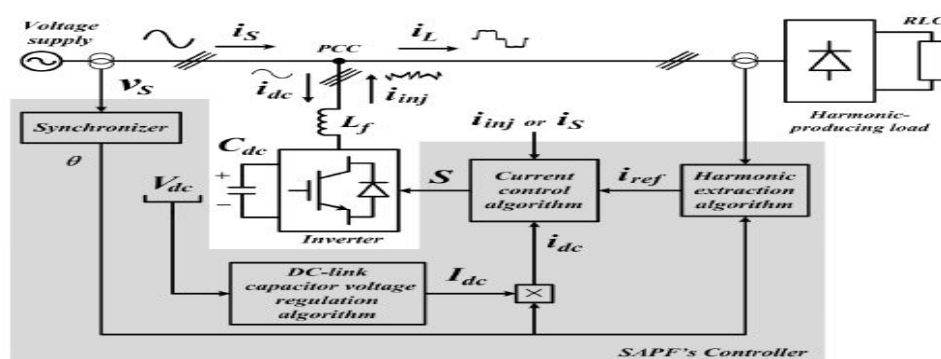


Fig. 1 Typical shunt active filter configuration

II. SHUNT ACTIVE FILTER AND CONTROL ALGORITHMS

Figure 1 shows the circuit configuration of the shunt active power filter of a voltage source inverter based shunt active power filter configuration. Generally SAPF is connected in the point of common coupling between voltage supply and nonlinear load or harmonic producing loads. The structure of SAPF is mainly consists of two main elements, a standard two level voltage source inverter and its control system. Meanwhile its controller has four main algorithms, harmonic extraction (known as reference current generation), DC link capacitor voltage regulation, current control (switching), and synchronizer algorithm.

1. Harmonic extraction algorithm- This algorithm operates by taking the load distorted current from the power system, followed by isolation of harmonic and fundamental current components and ends with the generation of reference current signal i_{ref} . The generated signal is used to govern the operation of SAPF in reducing the harmonic distortion.
2. DC Link capacitor voltage regulation algorithm- This algorithm take the instantaneous value of DC link capacitor voltage V_{dc} and compares with the desired reference value, the resulting error is used to calculate the suitable magnitude of DC link charging current i_{dc} , the i_{dc} needed to be drawn by SAPF to reduce the switching losses so a to maintain a constant DC link capacitor voltage.
3. Current Control Algorithm- This algorithm takes the output of the harmonic extraction and DC link capacitor voltage regulation algorithm to maintain switching pulses and a current loop that ensures the injection current i_{inj} is generated according to the reference current.
4. Synchronizer algorithm- This algorithm takes the source voltage signal V_s and generates a synchronisation angle or phase so that injection current i_{inj} which is injected by the SAPF into the power systems synchronized with the source voltage.
5. Voltage source inverter- This is a power converter designed to reproduce the reference current I_{ref} as injection current i_{inj} at suitable magnitude and it is equipped with DC link capacitor to compensate real power unbalance that occurs during dynamic operation of the SAPF to reduce the ripples of injection currents.
6. Harmonic producing loads- This is a nonlinear load which injects harmonic currents in the system through the point of common coupling PCC, SMPS, rectifiers, arc furnaces and rectifiers are the few examples of practical loads that generate major amount of harmonic currents and reactive power system.

III. PROPOSED MODEL

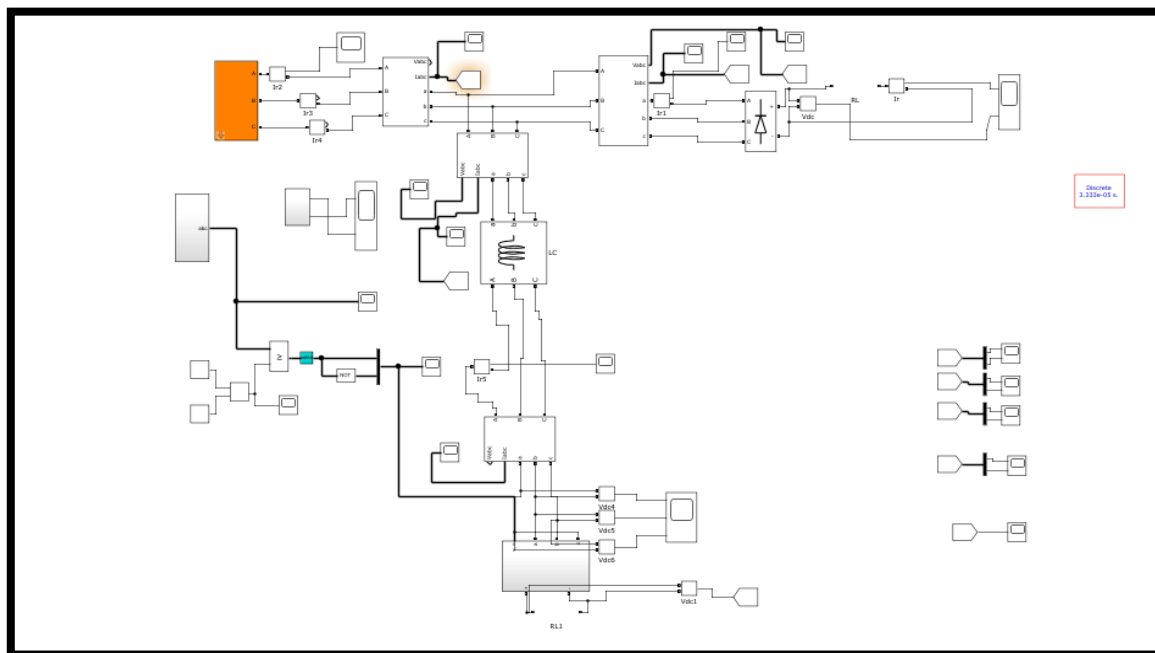


Fig. 2 Proposed Model

The work is based on the mitigation technique by using active filters like shunt active filter is used in this work for the elimination of harmonics and reduce the levels in the limits permitted. The nonlinear loads are the main source of harmonics generation connected in the power system and various number of problems like voltage sag and swell, voltage flicker and other power quality issues. To resolve this issue shunt active power filters are being modelled and analyze the results. The roles and actions of shunt active power filter depends upon the control system selected for the operation and this system of control plays an important role in the reduction of harmonics in the system.

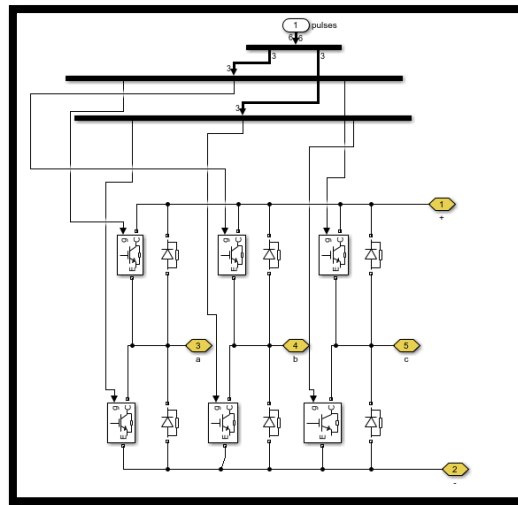


Fig. 3 IGBT bridge of active filter

A simple technique for the harmonic elimination is the injection of current in the system and is mostly applied for the harmonic simulation study. This idea treats the nonlinear load or harmonic generation load as an injection current source to the system assuming steady state condition. All nonlinear loads in the system are considered as the current injections of harmonic frequencies and therefore the principle of superposition can be apply.

IV. RESULT AND DISCUSSION

The output waveform of the designed model has been recorded for voltages, currents and other parameters in the output ports of the System.

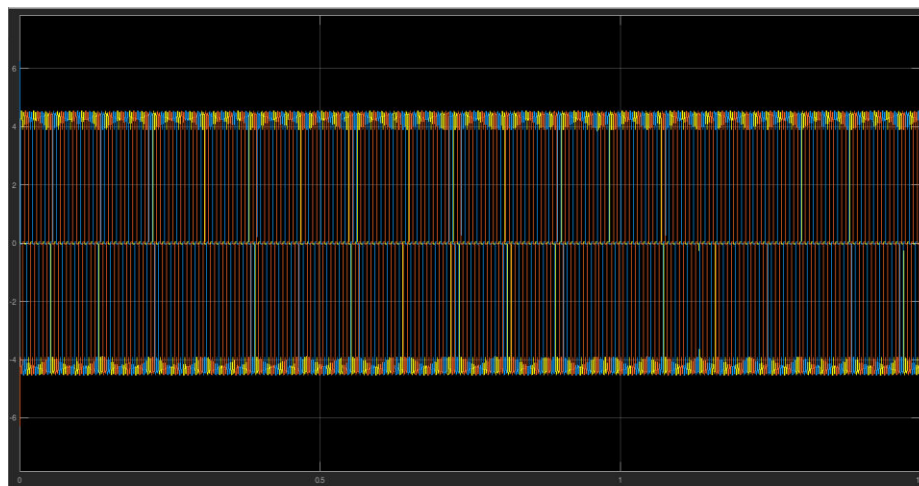


Fig. 4 Three phase voltage before inverter

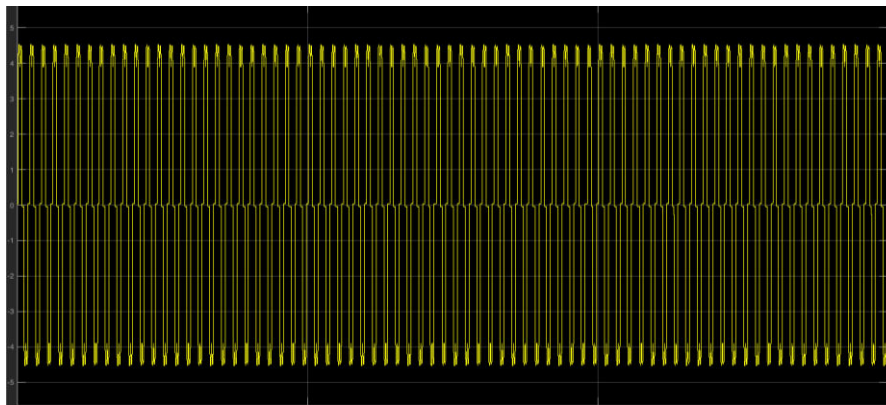


Fig. 5 Current before inverter

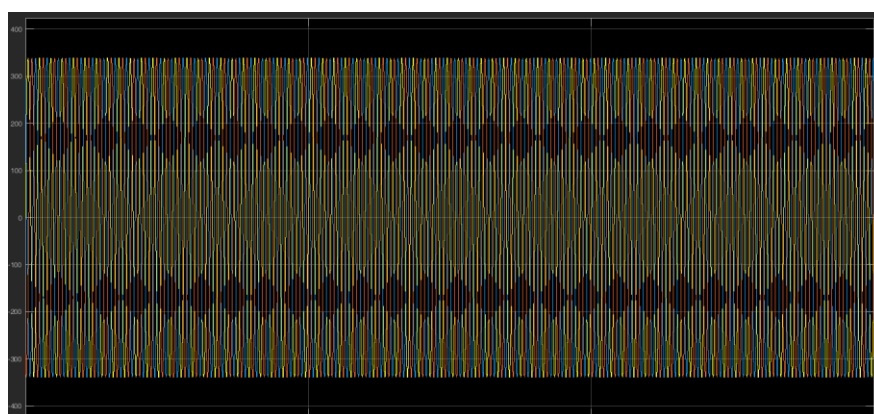


Fig. 6 Three Phase voltage at output

V.CONCLUSION

As per the statistics we can see the harmonics filter markets are growing rapidly in the last few years and it seems that the reduction techniques of harmonics will also be in a forwarding stage so analysis is necessary for the calculation, measurements and reduction techniques awareness for the harmonics in the system.

In this paper a shunt active power filter has been installed with synchronous reference frame theory for the better performance of a three phase three wire distribution system to improve the performance under non sinusoidal waveform condition. This method has the ability to reduce the harmonics in a specified controlled limit defined by IEEE and reduce the losses.

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