ABSTRACT

In recent years, quality of input power is a major cause of concern for electrical and electronic devices as well as electrical power consumers. Harmonic distortion is one of the critical power quality issues, caused by non-linearity of utility/industrial loads like Uninterruptable Power Supply (UPS), Variable Frequency Drives (VFD), induction furnaces, arc welding machines, conventional/Switched Mode Power Supply (SMPS) and battery charging units. Rapid growth of small and large scale grid-connected renewable energy sources injects harmonics into the power system network. The negative effects of harmonics are conductor overheating, degradation of capacitor life, false operation of circuit breakers, and increased iron and copper loss in transformers, generators, and distribution lines. The international standard IEEE 519-1992/2014 specifies the voltage and current harmonic limits for various voltage levels. In India, Central Electricity Authority (CEA), and State Electricity Regulatory Commissions (SERC) specify the current harmonic regulations. As per Tamil Nadu electricity regulatory commission, a penalty has been imposed for those customers who fail to maintain the current harmonics below the permissible limits as specified by CEA regulations. However, several case study reports by Asia Power Quality Initiative (APQI) show that possibilities for huge energy saving options are available by improving the quality of power.

Voltage Source Inverters (VSIs) are the very widely used and proven technology in different applications to control the output voltage magnitude, phase angle, and frequency. The benefits of active power filters have become widely recognized by power quality related industry and researchers. Pulse Width Modulation (PWM) rectifiers and shunt connected active filters play a major role in enhancing the distribution system operation, control, and improvement of power quality. The shunt connected active filters mitigate the

harmonics irrespective of the connected load based on its maximum capacity, whereas the PWM rectifier controls the current harmonics and maintains the unity power factor operation only to the specific load. The objective of this research is to study the Shunt Active Power Filter (SAPF) topologies and investigate the influence of PWM strategies in the three-phase boost rectifier performance.

Power electronics based Adjustable Speed Drive (ASD) system has many benefits in terms of energy efficiency and controllability but it acts as a major source of harmonics in the distribution system. In the recent years, researchers have been using DC-link inductor and AC-choke to reduce the source side current harmonics. In these techniques, the overall size of the drive system is increased. In this research, a new AC drive topology is proposed and investigated using two-leg VSI based DC-link SAPF to reduce the DC-link inductor size and improve the input current wave shape of AC drive system. The test result proves that the proposed DC-link SAPF effectively shapes the input current into a quasi-square wave with reduced DC-link inductor.

Harmonic reduction already installed in non-linear variable loads has been effectively handled by the three-leg VSI based shunt connected active filters. In this research, two different sensorless three-leg SAPF topologies are proposed and compared with the conventional vector controlled SAPF. The proposed techniques are analyzed under variable and unbalanced load conditions, and also for variable input voltage magnitude conditions. The test result reveals that using three-leg VSI based SAPF effectively mitigates the current harmonics under three-phase balanced load condition but it is not capable of controlling the neutral current through the distribution system under unbalanced single-phase loads.

In order to avoid the neutral current flow through the distribution system, a four-leg VSI based SAPF topology is appropriate. One of the objectives of this study is to use four-leg VSI to mitigate the current harmonics and to control the neutral current locally. A finite control set based optimized Model Predictive Current Control (MPCC) of four-leg SAPF suitable for three-phase, four-wire AC system is proposed and analyzed under dynamic conditions to mitigate the current harmonics.

The other objective of this research is to investigate the influence of PWM strategies in the performance of PWM rectifiers. To improve the performance of the PWM rectifier, a new Sampled Amplitude Pulse Width Modulation (SAPWM) is proposed for three-leg VSI based scalar controlled boost PWM rectifier and the same is analyzed in the three-phase Wind Energy Conversion System (WECS). The test result proves that the proposed scalar controlled PWM rectifier is the most suitable for low power WECS. The hardware implementation is done for scalar controlled three-phase three-leg boost PWM rectifier using DS1104 dSPACE kit along with the Semikron inverter module. The vector controlled three-phase VSD is the most popular method for medium power applications. In order to investigate the performance of the three-leg VSI based boost PWM rectifier suitable for VSD, a vector controlled boost PWM rectifier is modelled. Different Bus Clamping Pulse Width Modulation (BCPWM) techniques are used to compare the performance of the proposed vector controlled PWM rectifier.