A survey on single phase active power filter using hysteresis controller

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ABSTRACT

In this paper a single-phase active power filter is connected to a single-phase grid with non-linear load. The single-phase active power filter mitigates the harmonics generated by the non-linear load connected at PCC. The harmonics generated by the non-linear load are redirected to active power filter direction so as to avoid injection into the source damaging it. The novel single phase active power filter has half bridge connected to share capacitors. The reduction in source current harmonics with the use of hysteresis controller

Keywords:-shunt active power filter, parabolic PWM, harmonics mitigation power quality; power factor improvement.

1.1 INTRODUCTION TO POWER FILTERS

Filters are the networks that possess the property of differentiating between the signals of various frequencies and passing the signals of specific frequency only while the signals of the other frequencies not belonging to this range are suppressed or attenuated. The frequencies that are allowed to pass through the filters are termed as pass band and the frequencies that are totally suppressed or attenuated are termed as stop band or attenuation band. The frequency that separates the stop band and pass band is termed as cut-off frequency.

1.2INTRODUCTION TO ELECTRICAL POWER QUALITY

Electric power quality can be described as the degree to which the voltage, frequency and waveform of a power supply system match to established specifications. A good power quality can be stated as a steady supply voltage that remains within the prescribed range, a steady ac frequency that is close to the rated value and smooth voltage curve waveform preferably a sinusoidal wave. In other words it can also be stated as the compatibility between output of an electric outlet and the plugged in load. In absence of proper power, an electrical device tends to malfunction, prematurely fail or not at all operate. While "power quality" is a suitable term but actually it is the quality of the voltage rather

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than power or electric current that is actually described by it.

The power quality may be expressed as a set of values of parameters, such as:

- Continuity of service irrespective of voltage sag/swell
- Voltage magnitude variations
- Transient currents and voltages
- Harmonics in the waveforms

Compatibility is the major term associated with power quality and the problems associated with it usually have two solutions: i.e. either to clean up the power or to make the equipment stronger.

The CBEMA curve, gives the characteristics of tolerance of data-processing equipment to voltage variations, and also gives the duration and magnitude of voltage variations that can be tolerated. (CBEMA Curve: Ideally, an AC voltage is supplied in form of a sinusoidal waveform having an amplitude and frequency given by national standards or system specifications with an impedance of zero ohms at all frequencies.)

1.3 POWER CONDITIONING

Modifying the power to improve its quality is termed as power conditioning.

In presence of transients in the system an uninterruptible power supply can be used to switch off of mains power. A high-quality UPS units make use of a double conversion topology that breaks down incoming AC power into DC, charges the batteries and then remanufactures an AC sine wave, which is of higher quality than the originally fed AC power. Electronic filters can be used to remove harmonics. For series voltage sag compensation a Dynamic Voltage Regulator (DVR) and static synchronous series compensator (SSSC) are utilized.

In case of over voltages, a surge protector or a simple capacitor or a varistor can be used, while a lightning arrester can be used in case of severe spikes.

2 LITERATURE REVIEW

B. Singh, K. Al-Haddad and A. Chandra et al. [1] Active filtering of electric power has currently become an established technology for harmonic and reactive power compensation in two-wire, three-wire and four-wire AC power networks carrying nonlinear loads. Here a comprehensive review of active filter configurations, control strategies, selection of components, other related economic and technical considerations, and their selection for specific applications is been discussed.

T. C. Green and J. H. Marks et al. [2] there are many proposed variants of the active power filter and these variations envelop both the circuit topology and the control system used. Some of the control variants reveal different control objectives but there are still various variants within analogous ideas. The available control techniques are expressed and contrasted in a structured way to identify their performance strengths.

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Zhaoyang Yan and Guiping Zhu et al. [3] Active Power Filter (APF) is an important power electronic device used to compensate the load harmonic current so as to improve power quality of the system. Stability of voltage across the capacitor in DC side of APF is one of the key factors that determine the compensation effect. Therefore, voltage ripple must be controlled within allowed range.

T. Thomas, K. Haddad, G. Joos and A. Jaafari et al. [4] In the single-phase mode, the active filter can reduce the low frequency harmonic content in the AC line to below 1% excluding the harmonics due to switching action of the converter. In the three phase mode, line currents are corrected under balanced and unbalanced conditions. The neutral current is reduced significantly.

H.Kuo, S.Yeh and J.Hwang et al. [5] depicts a simple analytical model for the design and implementation of a three-phase active power filter controller. Voltage de couplers and pole-zero cancellation are used in current regulators so as to simplify the current control plant to a first-order delay type. This simplification is made by considering the delay times caused by the low pass filter of reference current calculation circuits, line inductors of an active power filter and the feedback circuit of a DC-link voltage.

N. Mendalek, K. Al-Haddad, F. Fnaiech and L. A. Dessaint et al. [6] have showcased the modelling of and a nonlinear control strategy for, a three-phase voltage source shunt active power filter. The dynamic model is initially elaborated in the system 'abc' and then transformed into the synchronous orthogonal 'dq' frame. The 'dq' frame model is divided into two separate loops, namely the two current dynamics inner loop and the DC voltage dynamics outer loop. The exact feedback linearization theory is applied in the design of the controller.

3. PASSIVE FILTERS

Passive filters are inductance, capacitance, and resistance components configured and calibrated to control harmonics. Techniques of passive filtering that make use of

- Single or double-tuned filters that at some frequencies have a low impedance path to harmonic currents.
- High or band-pass filters that can filter harmonics over a certain frequency bandwidth (damped filters).

3.1 SERIES ACTIVE POWER FILTER

The series active power filters compensates for the distortion of the current system induced by non-linear loads by applying high impedance path to the current harmonics that causes the high frequency currents to flow through the passive LC filter that is connected to the load in parallel. By creating a same frequency voltage as the current harmonic portion that needs to be removed, the high impedance imposed by the active power filter sequence is generated. The voltage difference is fixed by compensating for the system's underlying

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negative frequency and zero series voltage elements.

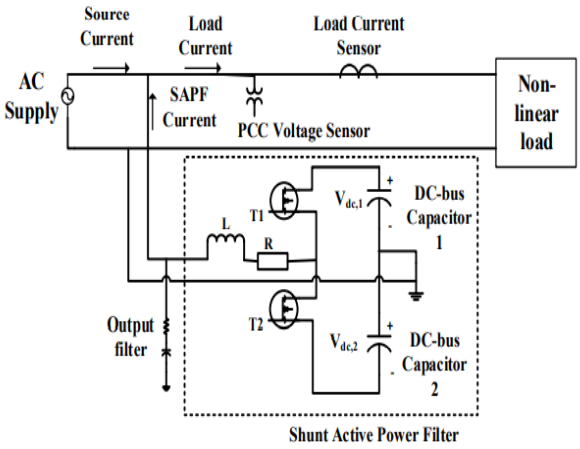
3.2 SHUNT ACTIVE POWER FILTER

By injecting equal-but-opposite harmonic compensating current, the Shunt APF compensates for current harmonics. The shunt active power filter works as a current source injecting harmonic components produced by the load but phase shifted by 180 degree. Every type of load is considered to be a harmonic source and is subject to this concept. Also, the active power filter may also counterbalance the load power factor with an acceptable control scheme. This shunt-connected system can carry out load compensation while connected to the load terminals, i.e. harmonic filtering, load balancing, power factor correction etc. When attached to a distribution bus, it can also perform voltage control.

4.METHODLOGY

4.1 POWER CIRCUIT OF SINGLE-PHASE SHUNT ACTIVE POWER FILTER:

The below figure 1 showcases, the Matlab model of single-phase shunt active power filter. It usually consists of two parts i.e., power electronic converter and efficient switching controllers. The power section of the SAPF consists of a voltage source inverter and the control section of the SAPF consists of DC bus voltage regulator, Reference current generation block and current controller along with gate signal generator. The PI controller of the DC bus voltage regulator maintains capacitor voltage. The reference current generation block computes the harmonic part of the load current and generates reference current for the harmonic generation. The current



controller, along with gate signal generator, controls switching, of the current injecting inverter.

Figure 1 Power circuit of single-phase SAPF

HYSTERESIS PWM FOR CURRENT CONTROL

Hysteresis current control is a method in which the required triggering pulses are generated by comparing the error signal to that of hysteresis band and then is used for controlling the voltage source inverter such that the output current generated from the filter would follow the reference current waveform as shown in Figure 2.

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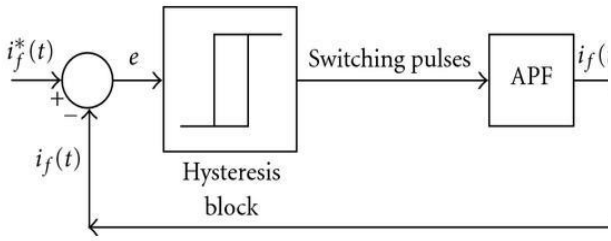

Figure 2 Hysteresis Control

In this method the switches of the voltage source inverter are controlled asynchronously to ramp the current through the inductor up and down, so that it follows the reference current. Hysteresis current control is the basic control method used to implement in the real time. Some of the better properties possessed by hysteresis band current controllers are robustness, excellent dynamics and fastest control with minimum hardware.

5. CONCLUSION

In this paper, hysteresis control is applied in the design and simulation of a single-phase shunt active power filter. It is clear that the proposed shunt active filter can adequately compensate for harmonic currents produced by the non-linear load. Self-charging capability in a PI controller was also successfully implemented int the proposed SAPF to regulate the dc capacitor voltages.

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