A Time Domain Reference-Algorithm for Shunt Active Power Filters

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Abstract

The aim of this paper is to identify an optimum control strategy of three-phase shunt active filters to minimize the total harmonic distortion factor of the supply current. Power Quality (PQ) is an important measure of an electrical power system. The term PQ means to maintain purely sinusoidal current waveform in phase with a purely sinusoidal voltage waveform. The power generated at the generating station is purely sinusoidal in nature. The deteriorating quality of electric power is mainly because of current and voltage harmonics due to wide spread application of static power electronics converters, zero and negative sequence components originated by the use of single phase and unbalanced loads, reactive power, voltage sag, voltage swell, flicker, voltage interruption etc. The simulation and the experimental results of the shunt active filter, along with the estimated value of reduction in rating, show that the shunt filtering system is quite effective in compensating for the harmonics and reactive power, in addition to being cost-effective.

Keywords: Shunt voltage inverter APF, Time domain, instantaneous active power, carrier based PWM, Control strategy etc.

I. INTRODUCTION

The wide use of power devices (based on semi-conductor switches) in power electronic appliances (diode and thyristor rectifiers, electronic starters, UPS and HVDC systems, arc furnaces, etc…) induces the appearance of the dangerous phenomenon of harmonic currents flow in the electrical feeder networks, producing distortions in the current/voltage waveforms. As a result, harmful consequences occur: equipment overheating, malfunction of solid-state material, interferences with telecommunication systems, etc… Damping harmonics devices must be investigated when the distortion rate exceeds the thresholds fixed by the ICE 61000 and IEEE 519 standards. For a long time, tuned LC and high pass shunt passive filters were adopted as a viable harmonics cancellation solution.

II. SHUNT ACTIVE FILTERING ALGORITHMS

The control algorithm used to generate the reference compensation signals for the active power filter determines its effectiveness. The control scheme derives the compensation signals using voltage and/or current signals sensed from the system. The control algorithm may be based on frequency domain techniques or time domain techniques. In frequency domain, the compensation signals are computed using Fourier analysis of the input voltage/current signals. In time domain, the instantaneous values of the compensation voltages/currents are derived from the sensed values of input signals. There are a large number of control algorithms in time domain such as the instantaneous PQ algorithm, synchronous detection algorithm, synchronous reference frame algorithm and DC bus voltage algorithm. The instantaneous PQ algorithm by Akagi is based on Park’s transformation of input voltage and current signals from which instantaneous active and reactive powers are calculated to arrive at the compensation signals. This scheme is most widely used because of its fast dynamic response but gives inaccurate results under distorted and asymmetrical source conditions.
III. TYPES OF THE ACTIVE FILTERS BASED ON TOPOLOGIES

A. Shunt Active Filter

B. Series Active Filter

C. Hybrid Active Filter
D. Unified Power Quality Conditioner

![Unified Power Quality Conditioner Diagram]

Fig. 4: Unified Power Quality Conditioner

IV. TIME DOMAIN METHODS

A. Instantaneous Reactive Power Theory

![Instantaneous Reactive Power Theory Diagram]

Fig. 5: Instantaneous Reactive Power Theory
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**Fig. 6:** Flow chart for the calculation of compensating current using instantaneous reactive power theory

**B. Synchronous Reference Frame**

- Non-linear load ➔ abc to DQ0 ➔ DQ0 HPF ➔ DQ0 to abc ➔ $i_c$

**Fig. 7:** Synchronous Reference Frame

**C. Sinusoidal Subtraction Method**

- Non-linear load ➔ Band Pass Filter ➔ ZCD ➔ PLL ➔ Sine Generator ➔ $i_c$

**Fig. 8:** Sinusoidal Subtraction Method
V. SIMULATION RESULTS

A. Simulation of Shunt Active Filter Based On P-Q Theory for Transient Load Condition

Fig. 9: Simulation Diagram of Shunt Active Filter Based on P-Q Theory for Transient Load Condition

Fig. 10: waveforms of phase-A (a) distorted load current (b) compensating current by filter (c) source current after compensation
Fig. 11: harmonics spectrum of phase-A (a) distorted load current (b) compensating current by filter (c) source current after compensation

Fig. 12: Wave Forms of (a) Distorted Load Current in Phase-A and (b) THD of Load Current (27.45%)

Fig. 13: Wave Forms of (a) Compensated Source Current in Phase-A, and (b) THD of Source Current (2.74%)
VI. CONCLUSION

In this paper, based on generalized active and reactive powers theory, in a-b-c reference frame-based a compensation algorithm for transient load conditions is proposed. This method has been verified by PSIM simulation. The proposed method can be applied to balanced and unbalanced source voltages in magnitude and phase angle.

REFERENCES