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Model Predictive Current Control of Single Phase Shunt Active Power Filter

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Abstract

A Model Predictive Current Control (MPCC) of single phase Shunt Active Power Filter (SAPF) is introduced in this paper. A single phase Voltage Source Inverter (VSI) is used as a SAPF to compensate the current harmonic and reactive power. A DC link capacitor voltage regulation based Proportional - Integral (PI) control algorithm is adopted for determining the reference current. A bridge rectifier with RL and RC loads are acting as a Non-Linear Loads (NLL). The harmonic compensation performance of SAPF and associated control methods like switch on response and transient responses were verified through a simulation with MATLAB software.

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Keywords: Model predictive current control, single phase shunt active power filter, total harmonic distortion

1. Introduction

The shunt active power filter mainly is made up of power electronic components and passive energy storage components which includes capacitors and inductors. The modern power electronic loads behave as NLL to generate the sizable amount of harmonics. Some examples of these loads are variable speed drives, switched mode power supply, electric furnaces, etc. Due to harmonic current presents in the power system which can affect the grid voltage and lead to numerous adverse effects which includes overheating of electrical equipment, interference in communication systems and failures of solid state equipment.

Usually, passive harmonic filters are mainly used in power systems to limit the current harmonics. But, they have many disadvantages such as tuning problems, large size and poor performance for mitigating high order harmonics.

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In order overcome these harms, the SAPF has been developed to compensate the current harmonic distortion. The single phase SAPF is normally used in educational buildings and commercial applications. The single phase SAPF operates at peak frequencies which also leads to attain improved performance condition [1-2].The SAPF performance mainly depends on two factors, first one is reference current extraction and second one is current control scheme. The reference current extraction has to be done by PI control algorithm scheme which is simple in nature to design and implement it for real time purpose.

And various methods have been proposed for current control of single phase SAPF such as PWM based control [3], hysteresis current control [4], double band hysteresis control [1] and predictive PWM control [6] method. From the literature it has been observed that there is a need of simple and accurate current tracking ability technique. Henceforth in this paper a MPCC algorithm is used in single phase SAPF due to its high accuracy, simple concept and easy addition of system nonlinearities. Recently many researchers show their interest towards MPCC for power converters [7-10]. Generally, in SAPF application the MPCC algorithm is used to control the SAPF power switches to generate the opposite harmonics and to inject them at the point of common coupling (PCC) for compensating current harmonic and reactive power. So in this manuscript the MPCC of single phase SAPF is introduced and a performance of SAPF and associated control methods like switch on response and transient responses were verified through a simulation with MATLAB software.

This manuscript is structured as follows. The model of single phase inverter is discussed in section 1. The control strategies of SAPF are presented with clear illustration in section 3. In Section 4, detailed simulation results are given. Finally the paper ends with suitable conclusion.

2. Single Phase Voltage Source Inverter Model

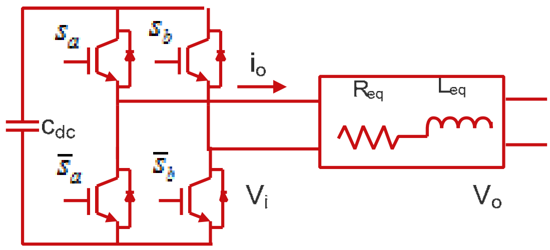

Fig. 1.Single phase VSI model.

The model of single phase VSI is presented in Fig. 1. The output voltage can be derived from DC link voltage and VSI switching states as follows

$$V_i = V_{dc}(S_a - S_b) \tag{1}$$

Where V_i - output voltage of inverter, V_{dc} - DC link voltage and S_a & S_b - control signal of inverter. The mathematical model of single phase SAPF from the Fig.2 is expressed as

$$V_o = V_i - R_{eq}i_o - L_{eq}\frac{di_o}{dt} \tag{2}$$

Where R_{eq} and L_{eq} are the equivalent resistance and inductance of single phase SAPF system.