Direct Power Control of Multilevel Inverter Based Active Filter

Mrs. Megha Patel¹ Dr. R. A. Yadav² Mr. B. R. Nanecha³
¹P.G Student ²³Professor
¹,²,³Tatva Institute of Technological Studies, Modasa

Abstract—A cascaded H-bridge multilevel inverter based active power filter with a novel direct power control is proposed in this paper. It can be directly connected to medium/high voltage power line without using the bulky transformer or passive filter. Due to the limited switching frequency (typically below 1 kHz) of high-power solid-state devices (GTO/IGCT), multiple synchronous/stationary reference frame current controllers are reviewed and derived. Based on this, a novel current controller is proposed for harmonic current elimination and system power factor compensation. Furthermore, a synchronous/stationary hybrid structure can be derived with fundamental decoupling control. The instantaneous reactive power theory and synchronous reference frame based control are compared based on mathematical models. A direct power control concept is then derived and proposed. It is equivalent as the hybrid synchronous/stationary frame current controller, but has a simpler implementation. It has clear physical meaning and can be considered as a simplified version of the hybrid frame current controller. Simulations on a 4160 V/1.2MVA system and experimental results on a 208 V/6 kVA laboratory prototype are presented to validate the proposed active power filter design.

Key words: Active Filter, IGBT, Medium Voltage, Multilevel Inverter

I. INTRODUCTION

Voltage source inverter based parallel active filter is known for current harmonic compensation of the power system and have been widely studied by using high switching power device (IGBT). For medium/high voltage application, a direct connected active filter can be more attractive by eliminating the bulky transformer or passive filter. Due to the limited switching frequency (typically below 1 kHz) of high-power solid-state devices (GTO/IGCT), multilevel inverters have to be used. This paper proposed a cascaded H-bridge multilevel inverter based active filter. Multiple techniques are studied to increase the system bandwidth at low switching frequency.

In recent years power electronic converters are widely used in industrial as well as domestic application for the control of power flow for automation and energy efficiency. Most of the time these converters draw harmonic current and reactive power from AC source and causes the power quality problems. There are number of devices available to control harmonic distortion. Passive filter are used for harmonic mitigation due to their advantage of simplicity, low cost and easy maintainance. But disadvantages that these filters introduce are numerous such as; the filter can be overloaded, parallel resonance between the power system and the filter, de-tuning of harmonic frequency with aging of passive components, and the filtering characteristics are dependent on the source impedance which is not exactly know.
B. Flying-Capacitors Multi-Level Inverters:
The flying capacitor multilevel topology was first proposed in 1992, and is considered to be the most serious alternative to the diode-clamped topology. The significant advantage of this topology is that it eliminates the clamping diode problems present in the diode-clamped multilevel topologies. Additionally, this topology naturally limits the dv/dt stress across the devices and introduces additional switching states that can be used to help maintain the charge balance in the capacitors.

C. Cascaded Multi-Level Inverter:
An alternative multilevel Inverter topology with less power devices requirement compared to previously mentioned topologies is known as cascaded H-bridge multilevel Inverter (CHB-MLI) and the topology is based on the series connection of H-bridges with separate DC sources. Since the output terminals of the H-bridges are connected in series, the DC sources must be isolated from each other. Owing to this property, CHB-MLIs have also been proposed to be used with fuel cells or photovoltaic arrays in order to achieve higher levels.

III. ACTIVE FILTER
A. Shunt Active Filter
It compensates current harmonics by injecting equal-but-opposite harmonic compensating current.

B. Series Active Filter
It operates as a current source injecting the harmonic components generated by the load but phase shifted by 180deg.

C. Hybrid Active Filter
By controlling the amplitude of the voltage fundamental component across the coupling transformer, the PF of the power distribution system can be adjusted.
IV. PWM TECHNIQUE

In many industrial applications, to control the output voltage of inverters is often necessary with varying the DC input voltage. With the help of the PWM techniques we can control the output voltage of the inverter and vary the gain of inverter.

There are number of PWM techniques are available to control the inverter output voltage which are as follows:

![PWM Techniques Diagram]

V. PWM CONTROL

Natural sampled PWM [10] is the best choice for applications modulation, such as active power filtering. It does not attenuate or distort the modulating signal, even when the frequency of that signal is similar to the switching frequency. Carrier based PWM [11] is also easily adapted to multilevel converter modulation by phase shifting the carriers. Although it appear more promising in theory, in practice as the number of converters increases, the variation between the analog generated carriers makes it increasingly difficult to achieve good carrier cancellation.

![Figure 8: PWM Technique]

VI. MATLAB SIMULINK MODELS

![Figure 9: The Topology Of Proposed Medium Voltage Multilevel Inverter Based Active Power Filter. Vs (Line-Line) = 4160V, R=26 , L = 0.15 H, Ls = 0.002–0.004H (5–10% Per Unit), Lf = 0.002H (5% Per Unit), C=1000_F, Vdc =1875V.]

![Figure 10: Multi-Sampled Phase Shifted Carrier Based PWM for Multilevel Inverter.]

![Figure 11: Basic Block Diagram of Multilevel Inverter]

![Figure 12: Simulink Model of Multilevel Inverter with Active Filter]

![Figure 11: Waveform of Voltage and Current]
VIII. APPLICATIONS

This multilevel inverter based active filter used in medium high voltage line.

IX. CONCLUSION

A multilevel inverter based direct power controlled active power filter for medium voltage application. With a very low switching frequency, the proposed active power filter can effectively compensate the dominant 5th, 7th, 11th and 13th harmonics.

REFERENCES

[6] H. AKAGI "Department of Electrical and Electronic Engineering, Tokyo Institute of Technology “Modern active filters and traditional passive filters”