듀얼 하프브리지 컨버터를 사용하는 파워 디커플링 DC/AC 인버터

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Power Decoupling of Single-phase DC/AC inverter using Dual Half Bridge Converter

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ABSTRACT

Nowadays, bidirectional DC-DC converters are becoming more into picture for different applications especially electric vehicles. There are many bidirectional DC-DC converters topologies; however, voltage-fed Dual Half-Bridge (DHB) topology has less number of switches as compared to other isolated bidirectional DC-DC converters. Furthermore, voltage fed DHB has galvanic isolation, high power density, reduced size, high efficiency and hence cost effective. Electrolytic capacitors always have problem regarding size and reliability in DC-AC single phase inverters. Therefore, voltage-fed DHB converter is proposed for the purpose of power decoupling to replace electrolytic capacitor by film capacitors. A new control strategy has been developed for 120Hz ripple rejection, and it was verified by simulation.

I. Introduction

As there is a need of high reliability with improved lifetime power conversion topologies for renewable energy systems and electrolytic capacitors are a source of reduced reliability with low lifetime. So, on this account, implementation of film capacitors instead of electrolytic capacitors is a better solution to increase reliability with improved lifetime. Dual Half Bridge (DHB) converter, voltage fed, has comparatively low count on switch, high power density, galvanic isolation, high efficiency and reduced size with film capacitors. The voltage-fed DHB converter, voltage fed has a control parameter phase shift which allows the control of output voltage as well as the output power. The boost action of voltage-fed DHB converter with phase shift control has an edge over other converter such as boost converter. Generally, boost converter can step up the output voltage up-to 5 times. In this paper, the voltage-fed DHB converter is used as power decoupling circuit due to the boost behavior, bidirectional power capability and control by phase shift. With the aid of phase shift, power transfer direction can be reversed. In the conventional paper, the decoupling is done by using the estimated reference. However, with the used control strategy in this paper, there is no need of estimated reference value for the elimination of double frequency ripple. In addition to elimination of double frequency ripple without the use of estimated reference, the other frequency ripple can also be eliminated without knowing the estimated reference.

In the following section, the proposed power decoupling circuit will be introduced and discussed and it will be followed by the control strategy. Finally, it will be verified by simulation results.

II. Proposed Power Decoupling Circuit

A. Theory of operation

Theoretically, for a single phase inverter, the required energy storage capacitor value to absorb the double line frequency power consumed component at the DC link can be obtained from the following equation(1) [1].

$$C = \frac{P_{DC}}{2\pi f_M V_{DC} \Delta V_{DC}} \qquad (1)$$

Where P_{DC} is the input DC power assuming lossless circuit, V_{DC} is the DC link voltage, ΔV_{DC} is the peak-to-peak DC-link ripple, and f_M is the line output inverter frequency. Therefore, the capacitor value is inversely proportional to the peak-to-peak ripple ΔV_{DC}. In the proposed topology, by allowing the auxiliary DC-link voltage to oscillate around a specified average value, the total capacitance will be reduced.

B. Proposed Circuit and Control Strategy

In this paper, DHB converter, voltage fed, is proposed as power decoupling circuit. The proposed circuit is shown in fig1.

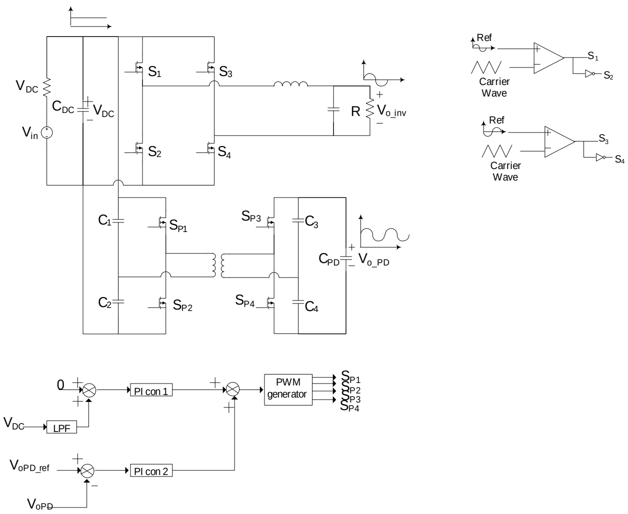

Fig. 1 Proposed Circuit and control strategy for Power Decoupling with voltage-fed DHB converter

By taking V_{DC} = 390V and the average voltage across the decoupling capacitor, C_{PD}, V_{oPD} =300V. The ripple peak to peak , ΔV_{oPD}, is considered to be 120V. With an output line frequency of 60Hz, and 1kW power generation, the required decoupling capacitance is 73.7μF. On the other side, without power decoupling circuit, and with 5% ripple voltage requirement, the DC link capacitor required need to be 348.8μF. It is clear that the required capacitor value in the proposed topology is comparatively very small.

The control strategy for the power decoupling is shown in fig. 1. PI con1 represents the PI controller for main DC-link ripple rejection, while PI con2 represents the PI controller for the average voltage control across C_{PD}. In the control strategy, PI con1 is carefully designed to reject the 120Hz ripple and to have higher bandwidth than PI con2 controller so the voltage across the decoupling capacitor can swing around the specified average voltage. The dynamics for the control loop PI con2 is chosen as fast as possible to regulate 120Hz ripple.

III. Simulation Results

The simulation results are shown in fig. 2. The simulation results show that the controller is working properly. In the simulation, the decoupling capacitance is taken as 75μF. The peak to peak ripple in the main DC-link is 11.32V (3%). And the average voltage across the decoupling capacitor is maintained at around 300V

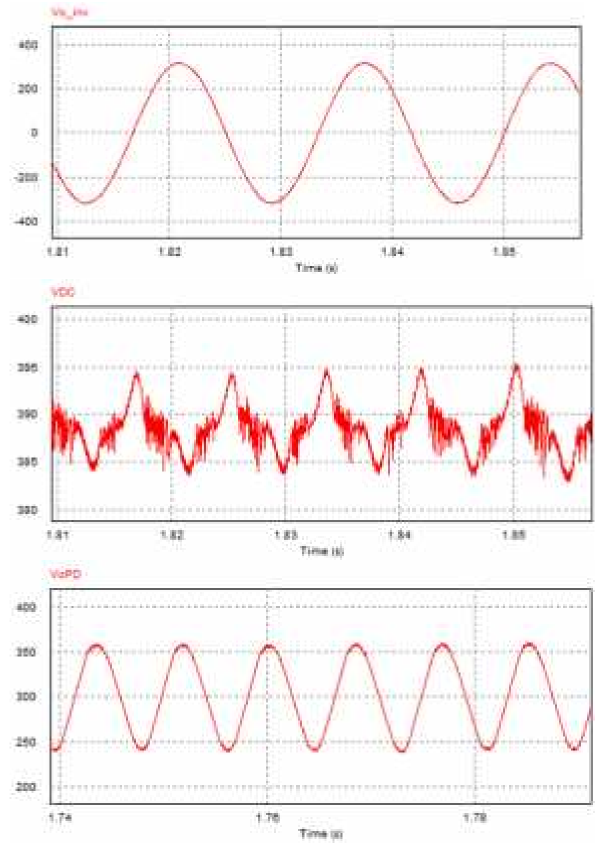

Fig 2: Simulation waveforms:Steady state response for inverter output voltage, voltage across main DC link, V_{DC}, and decoupling capacitance, V_{oPD}.

IV. Conclusion

This paper has proposed voltage-fed DHB converter as a power decoupling circuit with film capacitors. Reliability is improved by the implementation of film capacitors instead of electrolytic capacitors. The voltage-fed DHB converter has proved to be advantageous in regarding to power decoupling circuit. It has reduced the peak to peak ripple voltage across the main DC link capacitor to less than 5% of the main DC link voltage with the proper selection of the parameters of the controllers.

Reference

[1] Haibing Hu; Harb, S.; Kutkut, N.H.; Shen, Z.J.; Batarseh, I., "A Single-Stage Microinverter Without Using Electrolytic Capacitors," Power Electronics, IEEE Transactions on , vol.28, no.6, pp.2677,2687, June 2013.