ANALYSIS OF THE INFLUENCE OF SWITCHING RELATED PARAMETERS IN THE DAB CONVERTER UNDER SOFT-SWITCHING

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Abstract—An analysis of a dual active bridge (DAB) converter under soft-switching mode in the whole operating range is presented in this paper. A detailed study of the impact of the transformer magnetizing inductance, \(L_M\), and snubber capacitance, \(C_{xx}\), parameters on the soft-switching regions is carried out to obtain some design considerations. Simulation and experimental results which validate the theoretical analysis are also presented.

Keywords—dc-dc converters, dual active bridge converter, soft switching, modulation strategy.

I. INTRODUCTION

The dual active bridge (DAB) converter is suitable for applications that require high-power isolated DC-DC converters (Ioune and Akagi, 2007). The main characteristics of the DAB converter are high power density, operation under soft-switching mode and bidirectional and simple power flow control (DeDoncker et al., 1991; Xie et al., 2010). The DAB converter operating characteristics as well as a comparison with other topologies can be found in Steigerwald et al. (1996), Tao et al. (2008) and, Krismer and Kolar (2010).

For those applications that require a wide voltage ratio, as for instance energy storage systems, fuel cells, photovoltaic applications, etc. (Wang et al., 2007; Camara et al., 2010), the DAB converter is an interesting option but it presents a reduced soft-switching operating range limited to high output currents when the conventional modulation strategy (CMS) is used (Inoue and Akagi, 2007).

In Kheraluwala et al. (1992) it is considered the effects of the transformer magnetizing inductance and snubber capacitance on the operation of the DAB converter, concluding that these parameters significantly affect the soft-switching region.

In order to extend the operation range under soft-switching mode different modulation strategies are proposed (Oggier et al., 2006 and Jain and Ayyanar, 2008).

In Oggier et al. (2011) a new modulation strategy (NMS) to operate the DAB converter under soft-switching in the whole operating range and minimize the reactive power to reduce the conduction losses was proposed.

In this paper a similar analysis is presented but including the transformer magnetizing inductance and the snubber capacitance parameters. This analysis allows establishing guidelines for sizing these parameters in order to allow the DAB converter to operate under soft-switching mode in the whole operating range. Simulation and experimental results are included to validate the analysis.

The paper is organized as follows. Section I contains an introduction. Section II presents a power flow analysis using the NMS. The converter operation under soft-switching mode in its whole operation range is analyzed in Section III. The same section also contains guidelines for sizing the transformer magnetizing inductance and snubber capacitance. Simulation and experimental results are given in Section IV. Finally, conclusions are drawn in Section V.

II. POWER FLOW ANALYSIS

A complete analysis of the operation of the DAB converter using CMS can be found in Kheraluwala et al. (1992); DeDoncker et al. (1991) and Inoue and Akagi (2007). This Section presents a power flow analysis using the NMS.

A. Modulation Strategy

The NMS consists of driving the bridge with the largest dc voltage to generate a three-level PWM voltage waveform while the other bridge generates a constant frequency voltage square waveform with 50% duty cycle (Oggier et al., 2006; Oggier et al., 2009).