Grenze International Journal of Engineering and Technology, Jan Issue

Fuzzy Logic Control of Dual Active Bridge Converter for EV Application

Prof. Ravindra Mukund Malkar[1] and Prof. Vaibhav Baburao Magdum[2]
[1-2]Assistant Professor, Electrical Engineering Department, DKTE Society's Textile and Engineering Institute, Ichalkaranji, (MS), India.
Email: rmmalkar@dkte.ac.in, vaibhavmagdum@dkte.ac.in

***Abstract*—The demand of electric vehicles is booming on account of its advantages like reduced carbon footprint, economy of traveling, almost noise free operation etc. However, the construction of controller for electric vehicle is facing many problems in terms of suitability of power electronics drive, implementation of regenerative braking, selection of power converter, battery management etc. The DC to DC converter is an important element in electric vehicles and many researchers are focusing on development of bidirectional DC to DC converter and their control unit. A dual active bridge converter is a preferred choice for the same on account of its advantages like complete isolation between input and output, high voltage gain etc. This paper presents a fuzzy logic controlled bidirectional Dual Active Bridge converter for electric vehicle application. The fuzzy logic controller is developed by using MATLAB Simulink and simulation results are presented. The performance of developed controller is compared with PID controller for same converter.**

***Index Terms*— Bidirectional DC to DC Converter, Dual Active Bridge, DAB, Battery Charging, EV.**

I. INTRODUCTION

The DC to DC converters are categorized into isolated and non isolated converters. In isolated converters input and output are isolated from each other and have separate grounds. The coupling between the two is done with the help of transformer. Such converters are particularly suited for high voltage gains. By modifying the Transformer ratios voltage gain can be adjusted. These converters typically operate at low duty cycle ratio. Dual active bridge converter is isolated type bidirectional DC to DC Converter with full bridges on either side. These bridges are driven with square wave pulses of around 50% duty cycle and the power flow is controlled by using phase shift modulation. The bridge with leading phase angle delivers power to the bridge with lagging phase angle. A dual active bridge converter is being preferred on account of its advantages like galvanic isolation between low and high voltage side, adjustable voltage ratio and high efficiency.

II. LITERATURE REVIEW

A detailed review of DC to DC converters is presented in [1] along with a comparative study indicating advantages, disadvantages, applications and voltage gain. Based on the main classifications, the galvanic isolation is necessary for the high step-up voltage ratio since it offers better utilization for switching device and reducing the circulating reactive power [2]. The power transfer analysis of DAC converter and its operating

Grenze ID: 01.GIJET.9.1.513_1

modes through its operating modes controlled by the gate driving waveform [4]. The performance *of these* converters is characterized by knowing power flow handling, efficiency and accuracy. Among the DC-DC converters 'bi-directional dual active bridge (D AB) DC-DC converter' is preferred to improve overall efficiency, power flow and for fast response in electric vehicle applications and also in other applications [5].
A dual active bridge converter is controlled by phase shift switching strategy. Here, a DAB converter is connected in series with a bidirectional non-isolated buck boost converter. The single phase shift switching control technique achieves zero voltage switching over entire operating range. It knocks higher efficiency of 97% plus against conventional converter having efficiency near 95% [8]. A dual active bridge DC-DC converter for distributed energy resources and smart grid provides a high level of reliability and resilience to grid disturbances indeed the converter ensured a stable DC bus voltage when the micro grid was operated in islanded mode [10].
The performance of dual active bridge converter is further improved by implementing the converter with high frequency centre tapped transformer and modified phase shift control. The center-tapped inductor at the secondary side can provide the extra soft-switching current for the switches. Such an improved dual active bridge converter is appropriate solution for renewable energy applications subjected to large variations in input voltage. The modified phase shift control scheme works out the less soft-switching current at light load and the too large reactive power at heavy load, which increase the reliability and practicability of the converter [12].The use of dual active bridge converter simplifies connection of low voltage PV system with high voltage DC bus in renewable energy systems [15]. Even V2G and G2V interface configurations are simplified with DAB converter [16]. DAB converter can find application in battery management of electric vehicles wherein it can manage charging and discharging operation of battery. Researchers have obtained the maximum efficiency of DAB converter to be around 93% [17].

III. Dual Active Bridge Converter

The circuit scheme of a dual active bridge converter is shown in figure 1. Each full-bridge consists of two totem-poled switching devices, which are driven with complimentary square-wave pulses. The power flow in the dual active bridge can be directed by phase-shifting the pulses of one bridge with respect to the other.

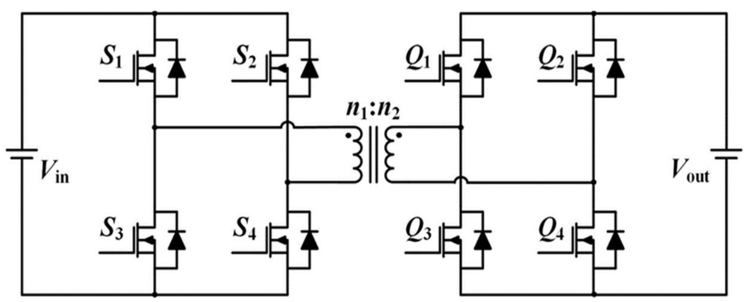


Figure 1: Circuit scheme of dual active bridge converter

A. Control System

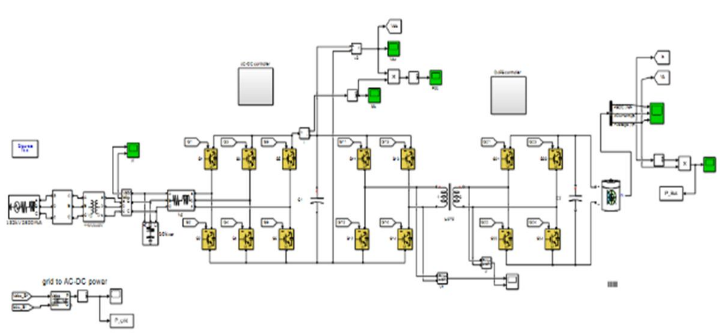


Figure 2: DAB converter based EV – Grid Interface

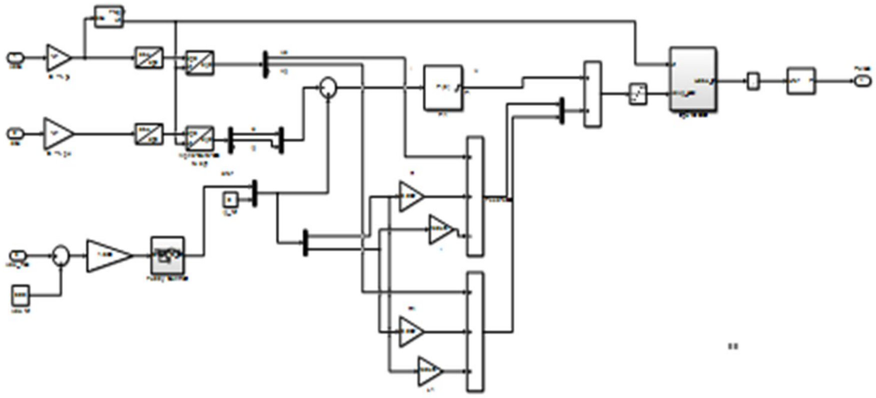


Figure 3: Fuzzy Logic Controller for DAB converter

IV. Results and Discussion

Mode 1: Grid to Vehicle Power Transfer

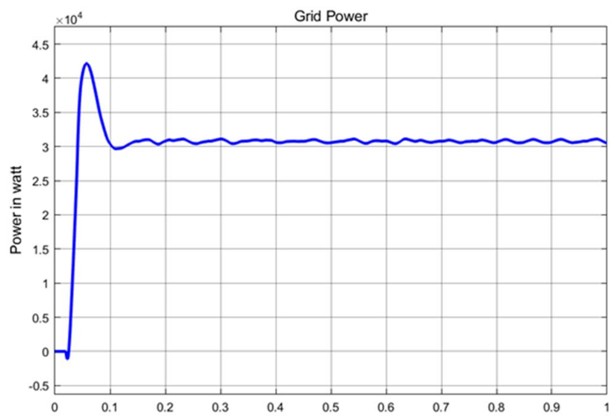


Figure 4: grid power

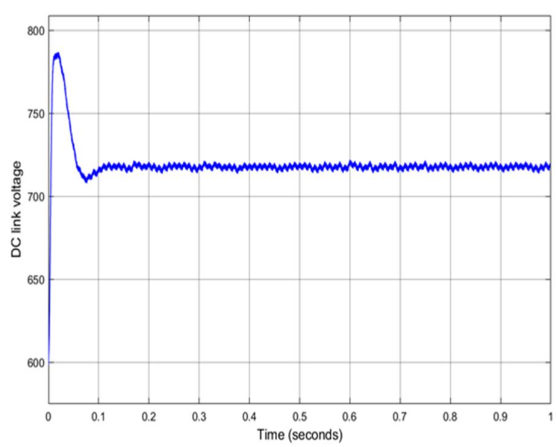


Figure 5: DC link Voltage

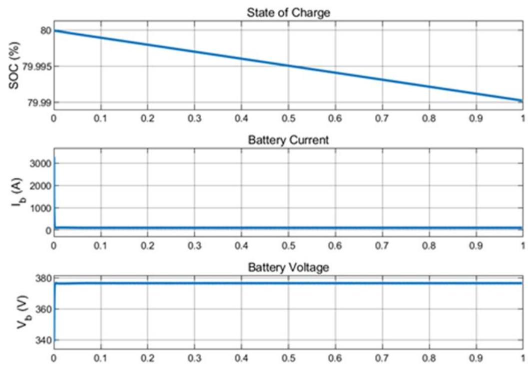


Figure 6: Battery SOC, current and voltage

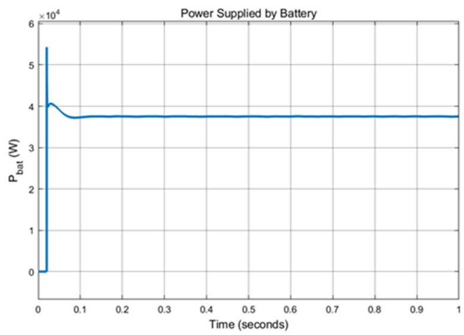
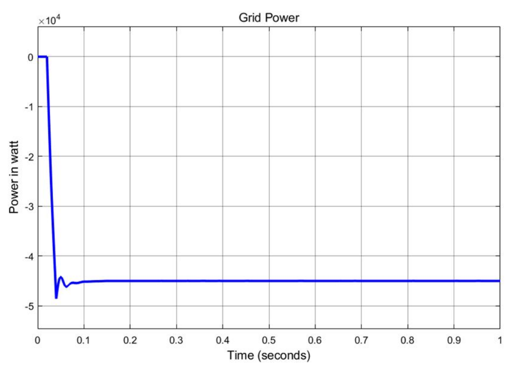
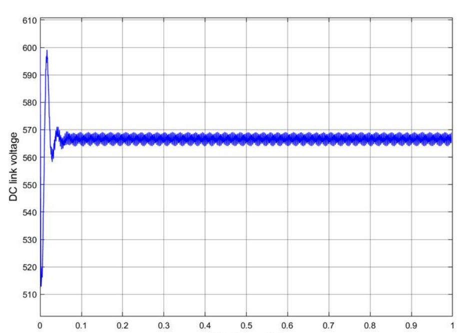


Figure 7:Power supplied by the battery

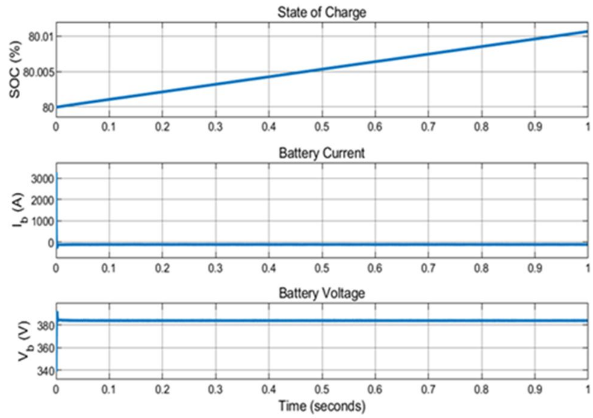
Mode2: Grid to Vehicle (G2V)



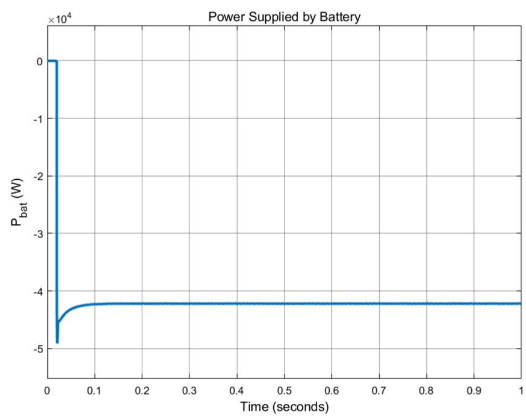
Grid Power



DC link voltage



Battery SOC, current and voltage



Power supplied to the battery

V. Conclusion

Fuzzy logic control of a dual active bridge converter for providing the interface between electric vehicle and grid is discussed here. The fuzzy logic controller gives improved voltage regulation at the DC link during power flow in either direction i.e. grid to vehicle or vehicle to grid. The converter control method can be applied for various applications with the advantage of high-power density and isolation. The proposed controller is easy to design and implement with least mathematical modeling, no linearization assumptions and thereby, avoid complex design.

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