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Development of a Cascaded Half-Bridge Converter with Contactless Transformer in DC Microgrid

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Abstract

A high efficiency cascaded half-bridge converter for contactless transformer with 1 A, 5 V and 600 kHz for mobile phone charger application is implemented in this paper by using simple PI discrete algorithm controller. The proposed target is to achieve the arch free, controllable voltage and galvanic isolation outlet and plug power transforming converter in a dc low voltage household power distribution. For the optimized outcome, the parameters are calculated and verified by MATLAB/Simulink program for bench testing. Additionally, this paper will be presented in both of the simulation and implementation results.

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*Keywords:*Coaxial contactless transformer, Contactless power transfer, Cascaded half-bridge converter

1. Introduction

Recently, there are many renewable sources connected to the utility grid in these days, such as photovoltaic panels or wind turbines. In order to manage the overall system, the smart grid has been introduced and become more attractive in the power distribution in recent years. Therefore, the enhancement of the household electrical devices is more concerned in order to synchronize with this smart system. The next step of dc to dc outlet and plug in household distribution[1][2] has been introduced for interfacing and monitoring in smart grid system as well. However, the risk of the electric shock on the direct metal contact is still a main problem of the power transferring in dc low voltage system. Therefore, this paper will introduce the contactless dc to dc outlet and plug by using high frequency switching converter on power distribution for home appliances.

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2. Cascaded half-bridge converter

The proposed paper presents the high switching frequency converter with contactless transformer for dc to dc outlet and plug application. The half-bridge converter has been used for medium size power transferring at range of 0-1A for mobile or portable electrical devices such as mobile phone battery. However, the conventional half-bridge switching topology has initiated the second harmonic which will affect the output voltage during the various load changing. Therefore, the cascaded half-bridge converter with the symmetrical switching topology is presented in order to eliminate the surplus voltage during load variation. Fig. 1.illustrates the scheme of cascaded half-bridge converter for dc to dc outlet and plug. The power density of the converter is designed to suit the old fashion outlet and plug with more than 600 kHz switching frequency parameters.

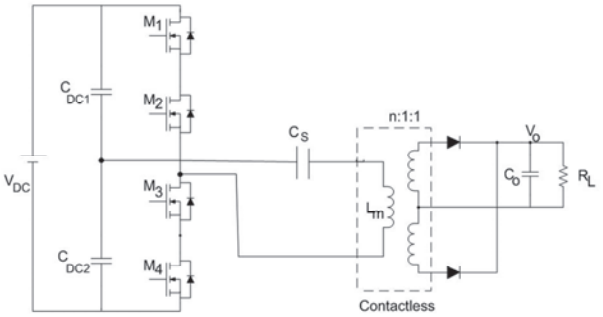

Fig. 1.Cascaded half-bridge converter

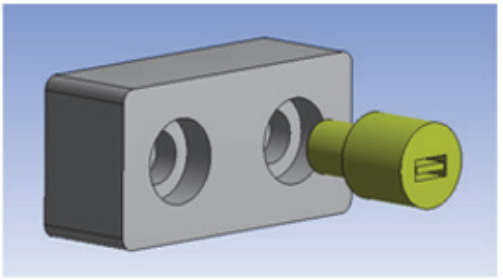

Fig. 2. Contactless plug and outlet design

The controlled algorithm is written in simple discrete PI, desired value or the setup point at 5 V the output voltage can be controlled and set by changing the proper alpha(α). In addition, the input voltage across the primary of the coreless transformer is delivered by the overlapping voltage of the M_1 and M_2 in positive portion with M_3, M_4 in negative portion, respectively, and compensated with appropriate capacitors and inductors.

Mainly, the power conversion for home appliance is a step down voltage conversion, The problem is how can we choose the proper converter for contactless power transfer. The phase shift pulse width modulation is normally applied to a full bridge converter because two legs can be controlled independently. Unfortunately, the output voltage is set only 5 V, so the half-bridge converter is chosen for this task for half voltage instead of using the full bridge converter. Switching pattern in Fig. 3.shows the fundamental component of the output voltage waveform which can be written in equation 1.

$$V_1 = \frac{V_{DC}}{\pi} cos \frac{\alpha}{2} \tag{1}$$

Obviously, the output voltage of the converter can be controlled by changing α. Additionally, the cascaded half-bridge converter with this switching technique does not contain second order harmonic, which makes this converter safe in the light load condition. The structure of this cascaded converter is able to reduce the voltage across the switching devices into half, which means that the switching device stress is reduced compared to conventional half-bridge converter as well.

3. Contactless power transfer

The light or optical system, acoustic system, electromagnetic wave, capacitive electric field coupling and inductive coupling system are used in power transferring methods. The cascaded half-bridge dc-dc converter with the inductive magnetic power transfer between primary coil and secondary coil has been proposed in this paper. Fig.